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Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Advt. Page 126, Aug. 13.
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(Signed) EDWIN DREW, J 95
July, 1920. Registrar.

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Two Steel Gas Holders, 40,000 cu. ft. capacity each.
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Five Settings of 6 Retorts, with necessary 6 in. Cast Iron Pipe.
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About 5 tons of Cast Iron connections underground.
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Detailed particulars, Permits to View, Tender Forms, which must be completed and returned not later than 10 a.m. on the 4th of September next, can be obtained upon application to the CONTROLLER, D.B.I.e., Plant & Machinery Section, Charing Cross Huts, Embankment, W.C. 2. J 256

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY OF COAL AND COKE during the period from 1st OCTOBER, 1920, to 30th JUNE, 1921.

The Metropolitan Water Board invite

Tenders for the Supply of

STEAM COAL and COKE to the various Pumping Stations of the Board, for a period of nine months from 1st October, 1920.
Forms of Tender and Conditions of Contract may be obtained on or after the 12th August, 1920, from the ENGINEER, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1, by personal application (Room 165), or upon forwarding a stamped addressed brief envelope.
Tenders, which must be on the official form, enclosed in sealed envelopes addressed to THE CLERK OF THE BOARD, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1, and endorsed "Tender for Coal and Coke," must be delivered at the Offices of the Board not later than Ten a.m. on Monday, the 6th September, 1920.
The Board do not bind themselves to accept the lowest or any Tender.
A. B. PILLING,
Clerk of the Board.
Offices of the Board,
173, Rosebery Avenue, E.C. 1.
27th July, 1920. J 193

CITY AND COUNTY OF NEWCASTLE-UPON-TYNE.

NEWCASTLE-UPON-TYNE CORPORATION ACT, 1904. QUAY EXTENSION: EAST OF OUSE BURN.

The Trade and Commerce Committee of the City Council are prepared to receive

Tenders for the Construction

and MAINTENANCE of a REINFORCED CONCRETE QUAY in the Hennebique System, 663 feet in length, on the River Tyne, East of the Ouse Burn.
On and after Monday, 23rd August, 1920, and after payment of £3 3s. to the City Treasurer, Town Hall, Newcastle-upon-Tyne (which sum will be returned on receipt of a bona fide Tender), copies of the General Conditions, Specification, Bill of Quantities and Form of Tender, can be obtained and drawings inspected at the Office of the City Engineer, Town Hall, Newcastle upon-Tyne.
Tenders, addressed to the City Engineer, and endorsed "Tender for Reinforced Concrete Quay," to be delivered not later than Ten a.m., on Monday, 6th September, 1920.
The Committee does not bind itself to accept the lowest or any Tender.
By Order,
A. M. OLIVER,
Town Hall, Town Clerk.
Newcastle-on-Tyne.
August, 1920. J 187

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD. (PLANT AND MACHINERY SECTION.)

For Sale by Public Tender.

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Three Hydrogen Exhausters, each 10,000 cu. ft. hourly capacity (Bryan & Donkin).
Two Lancashire Boilers, 7 ft. dia. by 30 in. (complete) and
Two Sets Forced Draught Furnaces for same (part finished).
One Lancashire Boiler, 6 ft. 6 in. by 30 ft. (only partly finished) and
One Set Forced Draught Furnaces for same.
One Hydrogen Station Meter, 37,000 cu. ft. per hour and
12 15 in. gauges.
Detailed particulars, Permit to view and Tender Forms can be obtained upon application to the CONTROLLER, D.B.I.e., Plant and Machinery Section, Charing Cross Huts, Embankment, W.C. 2.
Applications should be sent in not later than Ten a.m., September 7th, 1920. J 260

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TRIPLE EXPANSION STEAM DYNAMO AND BOILERS FOR SALE.

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One 500 k.w. Shunt and Compound Dynamo, 440 to 550 volts, by Siemens, coupled to triple expansion engine by Beilhs & Morcom.
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Coal Bunkers and Conveyor with Motors.
The above are for sale at Tynemouth Corporation Electricity Works and may be seen by appointment.
For further particulars apply to C. TURNBULL, M.I.E.E., Borough Electrical Engineer, Tynemouth. J 320

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Three LANCASHIRE BOILERS, 9 ft. by 30 ft. for 160 lbs. Practically in new condition, complete with Bennis Stokers, Greens' Economisers, and Superheaters, Damper Gear, Foreplates and Steam Piping.
Two WEIR PUMPS, to deliver 4000 gallons of water per hour.
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Apply, PRINCIPAL, Engineering College, Benares Hindu University.
Tel. "Benco" Benares. J 189

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R. MULLINEUX WALMSLEY, D.Sc.,
Principal. J 343

COUNTY BOROUGH OF WEST HAM.

MUNICIPAL TECHNICAL INSTITUTE, Romford Road, Stratford, E. 15.

Two Full-Time Assistant

LECTURERS and DEMONSTRATORS in Mechanical Engineering WANTED for next Session.
Salary £300—£15—£525 per annum.
Must be graduates of British University.
Applications, with particulars of qualifications and copies of recent testimonials, should be sent to the PRINCIPAL, Municipal Technical Institute, Romford Road, E. 15, not later than 5th September, 1920. J 190

COUNTY COUNCIL OF DURHAM.

EDUCATION DEPARTMENT.

HEATING ENGINEER.

Applications are Invited for

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Preference will be given to qualified engineers with experience in the preparation of plans and specifications, for and in the supervision and testing of heating schemes.
For particulars of appointment and form of application apply, enclosing stamped addressed foolscap envelope, to, THE DIRECTOR OF EDUCATION, Shire Hall, Durham.
Last day for receiving applications, Friday, 24th September, 1920.
Canvassing directly or indirectly is prohibited and will disqualify.
Shire Hall, Durham.
10th August, 1920. J 302

GOVERNMENT OF THE UNION OF SOUTH AFRICA.
IRRIGATION DEPARTMENT.

VACANCY FOR AN ASSISTANT BORING ENGINEER.

Applications are Invited

for the above-mentioned VACANCY.
CONDITIONS.
(1) Five years' contract.
(2) Salary £700, rising by annual increments of £40 to £900. No local allowance is payable.
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(6) If the successful candidate is resident outside the Union of South Africa, he will be given a free first class passage to the Union and return passage if not re-engaged at the end of his contract.
Applications and copies of testimonials as to character, qualifications and experience, all in duplicate, should be lodged with the SECRETARY, Office of the High Commissioner for the Union of South Africa, 32, Victoria Street, S.W. 1, not later than the 31st August, 1920. Applications may be submitted in such form as candidates consider most suitable for the purpose. J 189

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Applications are Invited for

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DARLINGTON TECHNICAL COLLEGE.

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R. WHALLEY,
Director of Education and Secretary.
Education Office,
Darlington.
August, 1920. J 161

TEMPORARY ENGINEERS REQUIRED IN CONNECTION WITH HYDRO-ELECTRIC SURVEYS IN BOMBAY AND BURMA.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will make

Six Appointments of

TEMPORARY ENGINEERS for employment in connection with the Hydro-Electric Surveys in Bombay and Burma. Candidates should be between 27 and 35 years of age. Associate Members of the Institution of Civil Engineers and Associate Members of the Institution of Electrical Engineers (London) will be eligible for appointment. Candidates should have a general knowledge of Civil Engineering, including Surveying and the use of the tacheometric plane tables, a sufficient knowledge of electrical power stations and distribution to enable them to draw up projects in the preliminary stages, and some experience of water power.
The appointments will be on agreements for three years with provision for extension by mutual consent. Pay from Rs. 675 to Rs. 1175 per mensem, according to age, commencing from date of reporting for duty in Bombay or Burma. Travelling allowances, leave and Provident Fund on usual conditions applicable to similar appointments in India. Free passages out and home.
Full particulars and forms of application can be obtained from the SECRETARY, Public Works Dept., India Office, Whitehall, London, S.W. 1, to whom applications for appointment should be submitted not later than 10th September, 1920.
India Office,
9th August, 1920. J 238

LONDON COUNTY COUNCIL.

HOUSING DEVELOPMENT SCHEMES.

APPOINTMENT OF ASSISTANT TO ADMINISTRATOR.

Applications are Invited for

the POSITION of an ASSISTANT to the ADMINISTRATOR of Housing Development Schemes. The appointment will be a temporary one. The person selected will be required to act as the principal assistant to the Administrator in the control and supervision of the large contracts for housing development schemes entered into by the Council. Candidates should be about 40 years of age, must have been trained either as civil engineers or architects, and have had considerable experience in the conduct of large construction works. Experience as a resident engineer or as an architect with outdoor experience on large construction works is required, and commercial knowledge gained on the staff of a large contractor would be a qualification. Preference will be given to candidates who have served, or attempted to serve, with His Majesty's Forces. Application must be made upon a form to be obtained from the Administrator of Housing Development Schemes, County Hall, Spring Gardens, S.W. 1. Stamped addressed foolscap envelope necessary. Candidates will be required to state on the application form the salary desired. All communications must be marked "Assistant to Administrator," and application forms must be received at the County Hall not later than 11 a.m. on Monday, 30th August, 1920.
JAMES BIRD,
Clerk of the London County Council.
J 297

MANCHESTER CORPORATION WATERWORKS.

LAYING OF AN ADDITIONAL PIPE LINE BETWEEN THIRLMERE AND MANCHESTER.

The Waterworks Committee require the

Services of Several Assistant

CIVIL ENGINEERS in connection with the laying of an additional pipe line between Thirlmere and Manchester.
Candidates must be good Surveyors, with experience in the preparation of detail drawings, specifications, and the setting out and laying of large pipe lines through difficult country.
Application forms, which can be obtained from the SECRETARY, Waterworks Department, Town Hall, Manchester, must be sent in not later than the 11th of September, 1920. J 357

Salesman, Tool Steels, Files,

MILLING CUTTERS, TWIST DRILLS, &c.—A SALESMAN is REQUIRED by the Indian Representatives of old-established Sheffield Manufacturers. Applicants must have experience of selling the above. The position will be a lucrative one for a gentleman with the necessary qualifications, and sound constitution. Applications, in which full details of experience, technical if any, age, and remunerations required, are to be stated, and which will be treated in the strictest confidence.—Address, J 287, Offices of ENGINEERING.

Planning Superintendent

WANTED by motor car manufacturers to develop Planning Dept., from existing Progress Dept. Experience of most modern planning methods essential. Should be conversant with stores systems. Practical knowledge of scientific management a strong recommendation. Must be keen, thorough, able to select subordinates, and have initiative. Progressive post. State age, salary required, full experience, and when at liberty. Address, J 271, Offices of ENGINEERING.

THE GRAPHITE INDUSTRY.

The reports issued from time to time by the Canadian Government through the Department of Mines have given much information concerning the mineral resources of the Dominion, the actual state of exploitation and the directions in which increased output is most promising. The most recent of these Reports relates to Graphite,* a mineral which is distributed fairly generally throughout the crystalline limestones and gneiss of the Archæan series of Eastern Canada, and can be mined with comparative ease in one or other of the forms known to commerce. It is to be feared that the graphite industry is in a depressed state, not only in Canada, but in Ceylon, whose supplies of plumbago have long dominated the market. Some of the causes of the present stagnation are of domestic origin and some are traceable to the disorganisation of trade and commerce through world disturbance, but these will be better understood if we describe, briefly, the forms of occurrence and the economic importance of graphite ores in the various trades in which the mineral is used.

Graphite, like charcoal and the diamond, is an allotropic form of carbon, and has often been confounded with the former and even with coal, but from these substances it can easily be distinguished by simple chemical tests. In mining operations, graphite is encountered in three separate forms. The most common is a so-called amorphous graphite, found in bedded deposits due to the metamorphism of coal or carbonaceous material. It also occurs in veins, then known as plumbago, and exhibits either a foliated or fibrous structure. The third form, known as "flake" graphite, is usually found in laminated or more or less flaky aggregates, disseminated in schistose rocks. Owing to the varied behaviour of some of these forms when treated with chemicals, it has been suggested that distinct varieties exist, and separate names have been suggested for the more marked variations, but the locality rather than the structure of the material is generally held sufficient to explain the characteristic appearances presented, and the differences detected are of chemical rather than of technical interest. So little do these forms vary in composition that the "amorphous" is really a crystalline graphite, whose particles are so small as to be indistinguishable to the eye, but under the microscope this earthy graphite is seen to be made up of finely crystalline material, and is therefore cryptocrystalline. Flake graphite differs from crystalline mainly in the manner of its occurrence. Each flake is a separate individual particle, crystallised as such in the rock. Crystalline graphite is found in the form of more or less well-defined veins, or in pocket accumulations. Both types of occurrence are fundamentally similar, only the shape of the ore bodies differs and also the amount of foreign mineral substances accompanying the ore. Vein graphite generally requires no other preparation for the market than is involved in a hand-cobbing process, followed possibly by screening. Amorphous graphite is commonly found in the form of minute particles more or less uniformly distributed through slates and shales, or in beds consisting practically entirely of graphite. Impurities, some of which are not easily removed, are generally present in all forms, and these include clay, oxide of iron, calcite, quartz and mica. The presence of the last named may render the graphite unfit for crucible manufacture, one of the main uses of graphite. Sulphur, also, is an undesirable ingredient for crucibles intended for melting silver and high grade alloys, as the combined iron gives rise to red spots on annealing. Since graphite, to be commercially successful, has to be placed on the market at less than 5 cents per lb., there is evidently little margin for the costs of refining and purifying, and therefore the freedom of graphite from undesirable gangue may become of greater importance than the carbon content of the ore.

The carbon content is not the only factor that determines the economic importance of graphite ores. The physical form, the relative refractoriness, and in the case of flake graphite the size of the flake, all exercise a considerable influence. As a rule the crystalline graphites and the flake command the highest prices and are the most expensive to mine. The world's demand is not large, being satisfied with about 30,000 tons of each kind annually. The marketing of each kind, however, presents considerable difficulty. The veins that contain the crystalline form of graphite are usually narrow and difficult to work, and the supply from Ceylon has acquired its paramount importance by reason of the cheap native labour available for the exploitation of the deposits. If white labour were employed the cost would prove prohibitive, allowing other and cheaper kinds to find a more extensive outlet. Indeed, the increase in the import of Madagascar flake graphite, where native labour is again advantageously employed, is exercising a most disastrous affect on the Ceylon market. As already mentioned in the case of "flake," the size of the flake is of importance, and the preservation of the size in the subsequent milling and refining processes, necessary to free the flake from the gangue and to remove impurities, presents unusual difficulties. Oil flotation may finally prove the solution of the difficulty which has long embarrassed the flake graphite industry. The percentage of graphite in the ore is of less moment than the size; ores running as low as 3 per cent. have been successfully treated in Alabama, though in this case operations are confined almost exclusively to the weathered rock above ground water level. The action of a muller pan or chaser mill is all that is needed to break the ores down sufficiently for concentrating. Amorphous graphite, the world's largest source of this mineral, amounting to about 80,000 tons annually, is easily mined, but rarely has a high carbon content and can only be advantageously employed in the less important applications of graphite to commercial purposes. It is used mainly in foundry facings and paints, since owing to the fine state of division of the graphite and the difficulty of separating it from its earthy matrix no high degree of purity can be secured.

The concentration and refining of graphite, particularly when in the flake form, to fit it for use in the various industries, is often a troublesome, and a not altogether satisfactory, process. In the case of high grade Ceylon plumbago, little difficulty is experienced. Simple picking and cobbing of the ore is sufficient to give a result averaging 90 per cent. carbon. Lower grade material is pulverised and washed by hand, the graphite being thrown off in the water, while the particles of gangue subside. After drying the graphite is winnowed by being placed in shallow baskets and thrown into the air, the heavier particles falling back into the basket, while the "flying dust" is blown forward and falls to the ground. Such a method is only possible where labour is cheap. On the other hand, amorphous graphite does not permit of refining, and on the American Continent no attempt at concentration is made. Such graphites vary greatly in carbon content, have small value, and must be adapted to meet the demands of the particular trade in which the material has to be used. High grade amorphous graphite, attaining in some Mexican specimens as much as 86 per cent., is used for pencils and for lubricants. More impure and harder kinds, more frequently encountered, carrying 35 per cent. to 50 per cent., are used for stove polish, shot polishing, &c., for in such trades high carbon content is not essential and a considerable proportion of clayey matter is not prejudicial.

The extraction and treatment of flake graphite, however, presents many difficulties requiring skilful technical handling to effect a successful result. The crude ore is associated—often to the extent of some 80 per cent.—with metals that differ but little in specific gravity from the graphite itself, while mica, already mentioned as one of the most objectionable impurities, is similar in hardness and toughness, and at all stages of mechanical treatment behaves in the same way as the associated graphite. Moreover, the crucible trade, which utilises nearly 75 per cent. of the recovered graphite, insists not only on 90 per cent. carbon content, but requires that the flake should pass a 20 mesh screen and be caught on the 90 mesh. Processes have been devised which have met these conditions but such results have almost always been achieved at the expense of recovery, and unless the method of oil flotation is employed the average loss of graphite in the tailings is not less than 50 per cent. of that contained in the ore treated. This loss is due to the fact that it is not possible to free the flake from the gangue without reducing it to a powdery form, the value of which is very small. Large flakes are frequently brittle, and break up in milling, while a smaller sized flake if tougher than the accompanying limestone, may better resist destruction in milling operations. In weathered surface schist, little grinding is necessary to free the flake, and a low grade graphite content in such circumstances may be utilised. Another frequent trouble, of commercial rather than technical importance, is the liability for the ore-body to alter its character in depth, and estimates of the graphite content of a deposit based on analysis of surface material are apt to prove misleading. For the same reason concentration tests of such material may yield results that lead to erroneous and disappointing conclusions.

Several methods of concentration have been employed. That known as the dry method was long practised, but is now being rapidly superseded by more efficient machinery. Two essentially dissimilar methods have been practised, but the same objections attach to both. One effects the separation of the graphite from the gangue by means of air jets in connection with pneumatic tables and jigs; the other produces the gradual elimination of the more brittle gangue constituents by passing the ore through a succession of rollers and screens. Both methods require the ore to be thoroughly dried before it enters the mill, involving a considerable expenditure in kilns and fuel. Both produce a large amount of objectionable dust and in neither is the recovery entirely satisfactory. The mica remains as an undesirable ingredient and the flow sheets, of which Mr. Spence presents several examples, show that a large number of belts and elevators are required, all requiring much attention and not infrequent repairs. Another dry method is based on the differing electrical conductivity of graphite particles from those of the adhering gangue. The mineral particles are passed through an electric field and the graphite grains being thus deflected from the course pursued by the gangue, can be retained by suitable means. A measure of success can be claimed for this process, but it does not seem to grow in favour.

These dry processes have not succeeded in displacing the wet methods as originally practised, which still hold their own and are particularly useful in dealing with highly decomposed surface ore, sufficiently soft to be crushed in a muller pan. Either mechanical washing, or buddles, will effect a satisfactory recovery from the general types of graphite ore and have the merit of being simple to operate and require little attention. The buddles used are of the circular type, about 16 ft. in diameter, and are credited with making concentrates approximating 80 per cent.

More interest attaches to the possibilities of flotation as a suitable process for the concentration of graphite ores. Two methods are in use, one known as frothing oil flotation and the other as surface tension flotation. These operations have been but recently introduced and can hardly be said to have passed the experimental stage. It is therefore too early to generalise on what either method can achieve, since a very considerable knowledge of the principles of flotation is necessary to arrive at the best results, and each mill requires some different treatment to be determined by the character of the ore, the size of the flake and other variables. Sufficient is known, however, to be able to say with some confidence that frothing oil flotation offers the cheapest and most efficient means of concentrating graphite that has yet been devised. The method utilises a property possessed by fine particles of certain minerals of floating up on the surface of a frothing liquid, while the gangue, or a great portion of it, will sink to the bottom. The reason for this selective action is not definitely known, and to ascribe it to a superior affinity possessed by metallic surfaces for air, which preference is enhanced by the presence on them of oil or grease, is merely stating the effect in another way. The fact remains, how-

* "Graphite." By Hugh S. Spence, M.E., Canada Department of Mines: Eugene Haanel, Ph.D., Director. Ottawa. 1926.

ever, that when the crude ore is made into a pulp with water to which a small proportion of frothing oil has been added, and a mass of bubbles created by mechanical agitation or the injection of air, the graphite particles become attached to the bubbles in the pulp and are carried by them to the surface where they may be skimmed off, or automatically carried forward by surface flow over the lip of the tank in which the operation is performed. This is the basic principle of oil flotation and is common to all methods. The variations consist mainly in the different means by which the air bubbles are produced. The air may be beaten into the pulp by paddles or stirrers, or be injected through a canvas or other suitable porous bottom, or by jets of water impinging on the surface of the liquid in the tank. Ball or pebble mills are generally used for grinding the feed for the flotation cells, and wet grinding seems to be growing in favour. All systems using oil flotation employ tanks in series for frothing the pulp. The first tank effects an initial concentration, and the concentrates from it pass to a second, and through as many as may be found necessary to raise the grade to the point desired. By introducing additional ball mills between successive tanks the concentrate made by the last cell can be raised to a high degree of purity. It may not, however, be possible to raise the carbon content beyond a certain point. In a trial analysis clean flakes, carefully picked from the flotation concentrates, showed only 92·25 per cent. carbon, and a microscopic examination proved the presence of quartz, mica, and pyrite intimately intergrown in the graphite flake.

Surface tension flotation depends on the ability of flake mineral particles to float on the surface of water without the addition of oil. This system offers the advantage of simplicity and cheap operation, but the percentage of recovery is not very satisfactory, rarely exceeding 50 per cent. to 60 per cent. of the graphite in the ore. The general process consists in allowing the ore to drop from a stock bin on to an inclined spreader plate. A baffle board permits the feed to flow quietly on to the surface of the water, when the heavier gangue particles sink to the bottom of the washer, while the graphite with an appreciable amount of fine dust gangue floats over into the collecting launder. For successful operation it is necessary that the ore is thoroughly dry before being fed on to the water surface, and some kind of roasting has to be practised. In any case, drying is necessary if the graphite concentrate is to be finished or refined with the view of increasing the graphite content. The usual plan for refining the concentrates, when necessary, is to pass them over burr stones followed by screening. The object is to subject the graphite flakes to a pressure that will pulverise the fine gangue contained between the lamina and to remove any mechanically admixed gangue particles. If a still higher grade graphite is needed recourse must be had to chemical methods.

The fortunes of the natural graphite industry will depend very largely upon the extent of the production of artificial graphite and the possibility of adapting the product to the manufacture of crucibles, electrodes, &c.; in fact, to invade the area covered by natural graphite. The American and Canadian works at Niagara produced in 1917 nearly 6,000 tons of artificial graphite, that came into direct competition with mined graphite. This does not include graphitised products, such as electrodes, for which there is a large market. This manufactured product, possessing a reliable and constant carbon content, is likely to be in increased demand, and probably new uses will be found for it, if it can be produced at sufficiently low prices. Where electric power is plentiful the process is simple and has been practised some twenty years. The raw material is anthracite coal and coal wastes, or culm, for it is found that the quantity of graphite obtained is considerably greater, and a better product is secured, when the coal used contains some amount of foreign mineral substance, or when a certain proportion of silica, clay, lime, or iron oxide is purposely mixed with the coal. The material is crushed fine, and placed in a furnace which is of long, narrow, trough-like form, with an electrode at either end. On passing a current through, innumerable small arcs are formed between adjacent particles, and the mass becomes incandescent, and is allowed to remain so till the carbon is converted into carbides of the various constituents of the ash. On carrying the temperature still higher these carbides are decomposed, and the silicon and iron and other minerals vaporised, the residue being a graphite, free from all trace of amorphous carbon. The temperature reached is in the neighbourhood of 7,500 deg. F., and at this temperature a purity of 99 per cent. carbon content can be guaranteed. The manufacture of electrodes and graphitised products is carried out in the same way, but a definite amount of carbide forming substance is added to the material whether anthracite or petroleum coke is used. The electrodes, formed under pressure in a mould or extruded through a die, are stacked in a furnace whose floor is covered with a thin layer of pulverised coal. The whole is covered with ground coke of about 2 mm. grain, and this is again covered with a mixture of sand and ground coke. The initial voltage used is 200, at which point it is maintained until 750 kw. are registered. As the resistance sinks the voltage is cut down proportionately, so as to keep the power consumption a constant. The alteration to graphite is complete, for when the product is treated with potassium chlorate and nitric acid no trace of amorphous carbon can be found. But the appearance and characteristics of the electrodes differ greatly according to the nature of the raw material employed. By tests they are all graphite, but they differ very materially in most of their physical properties. This difference of character, the origin of which is obscure, places limits to the possibilities of competition with natural graphite, but at the same time offers scope and opportunity for new applications.

An interesting feature in the behaviour of artificial graphite is its extreme divisibility. For lubricating purposes it is ground to 200 mesh, and in this form is well adapted for filling up the pores of metal and smoothing the microscopic roughness of surfaces in rubbing contact. The surfaces thus coated are covered with a veneer of graphite, which reduces their coefficient of friction to that of graphite itself, and produces practically a graphite-graphite contact in place of a metal-metal contact. But a so-called deflocculated graphite is of quite another order of fineness. In this state, brought about by treating finely ground graphite with a solution of tannin, it is claimed that the subdivision is not only finer than can be produced by mechanical means, but approaches the molecular form. The liquid passes through the finest filter paper and the particles are admirably adapted for exhibiting the Brownian phenomena. The erratic movements of the particles bring about collisions and coherence, collecting the graphite into small masses, which gradually become subject to the action of gravity and settle out. Various expedients have been resorted to in order to effect the permanent suspension of the graphite particles, but if successful it is doubtful whether this colloidal property would assist the solid lubrication it is the function of the graphite to perform.

The uses of graphite in commerce are varied, but the tonnage used is not very great. Crucible manufacture absorbs the larger portion, but the graphite of any particular grade can hardly be said to be indispensable to their production. Graphite is used because of its refractoriness and good conductivity, but it has no binding qualities, and clay has to be combined with it in varying quantities according to the kind of metal to be melted and the character of the fuel used. With so many variables, troubles with crucibles are frequent, and manufacturers have for some time past been inclined to substitute the electric furnace for the crucible in melting steel. Further, it is highly probable that the crucible will be similarly displaced in the brass industry. The ability to melt larger charges, the diminished loss of metal by oxidation, the absence of contamination by sulphur from the fuel, and other advantages, all speak in favour of electric furnaces, and point to a further decline in the demand for graphite. This decline is accentuated by the conditions that prevailed during the war. In the United States, the curtailment of imports of Ceylon plumbago, and Madagascar flake, led to the use of substitutes in crucibles, and experiments, undertaken by the Bureau of Standards to ascertain whether plumbago could not be replaced by other and native materials without any serious detriment to the crucibles so made, have met with considerable success. In 1915, owing to the demand for munitions and the restricted importations, great scarcity was experienced and high prices prevailed, with the result that best Ceylon plumbago rose from 9 cents to 30 cents per pound in 1917. A great impetus was given to the flake graphite industry in consequence. Domestic legislation in the States concerning importation led to feverish production, and further inflation followed, not entirely removed till 1919 when restrictions ceased. The trade is still suffering from inflation and uncertainty due to the extent of the competition of artificial graphite in lines of manufacture, hitherto occupied solely by flake graphite and plumbago.

Canada, with which Mr. Spence is more immediately concerned seems to be suffering more severely than the States. Canada has had no boom, but has had to endure the loss and inconvenience due to the retreat of the wave of prosperity that has enriched her powerful neighbour. The analyses of the author shows that internal conditions have contributed to the depression now prevailing. He points out that failures in graphite enterprises have resulted from the practice of inefficient and expensive methods of concentration that rendered profitable the treatment of only the richer portions of ore bodies, giving rise to neither a clean nor standard grade of product, and made but poor recovery of the graphite in the ore. In a number of instances, larger mills than were warranted by the known ore-bodies have been erected, and owing to lack of ore and heavy expenses of running have been only in intermittent operation. The industry in Canada, as in other parts of the world, is under a cloud, but Mr. Spence perceives a pronounced recrudescence of interest in the possibilities of Canadian graphite, and looks forward hopefully to a recovery from the depression, a recovery that will be assisted by a proper appreciation of the difficulties attending the development of deposits and the treatment of graphite ores. This excellent report reviewing the whole conditions affecting the welfare of the industry, the experience of the past and the opportunities of the future, should provide a fresh stimulus to exertion and awaken increased interest in one of Canada's many assets.

THE LOUGHBOROUGH TECHNICAL COLLEGE.

(*Concluded from page 202.*)

THE description we have so far given of the college buildings and equipment has concerned itself with the works, or factory side, of the Institution. This works, or factory, side is, as we have said, at present engaged in training large numbers of discharged soldiers so that they may take their place in some one or other trade. Concurrently, however, the shops are occupied by the students who are taking the various engineering courses. It will be very evident from our illustrations and from what we have said that a student spending any considerable part of his time in the college workshops, or in the Instructional Factory, as it is called, will gain a very different knowledge of engineering manufacture and modern shop processes from what can be gained in the mechanical laboratory, or workshop, of the ordinary technical school. In many ways, indeed, five years spent at the college with 50 per cent. of working hours given to the shops, can claim superiority over the same time spent in a commercial factory, even from the workshop point of view. We admit and recognise only too well that the final elements of the commercial atmosphere can never be induced in a college workshop, but think it will be generally admitted that as near an approximation as is possible has been made at Loughborough. The advantage of the Loughborough system, from the workshop point of view, is that practical training in, and experience of, the many varied trades which go to make up the activities of an engineering factory may be obtained by the students in a way that is not generally possible in the workshops of commerce.

The course in technical engineering at the Lough-

THE LOUGHBOROUGH TECHNICAL COLLEGE.

Fig. 20. The Heat Engine Testing Laboratory

Fig. 21. 80-Horse-Power Le Rhone Testing Set.

Fig. 22. 80-Horse-Power Le Rhone Testing Set.

borough Technical College covers three years, and may be extended to five. Although at least half the working time is spent in the workshops it will none the less be clear that a student taking the normal three years' course cannot hope in that time to become a fully-qualified tradesman in fitting, machine work, pattern-making, founding, &c. This, however, is not the object of the course, but the adequate practical knowledge of all these branches of work, which may be gained, is likely in after life to be a value to any engineer. There is, of course, nothing to prevent a youth from serving an apprenticeship of two or more years before or after taking the Loughborough course, and such a procedure would have advantage over the sandwich system in that the period of study would be unbroken, but at the same time would never be divorced from really practical work in the shops.

The time table of the course is arranged so that half the students spend the mornings of Mondays to Fridays in the shops, keeping factory time, from 8.30 to 12.30 and spend the afternoons of Monday to Friday, from 2 to 5 and Saturday morning from 9.30 to 12, on theoretical work; the other half of the students take the respective contra periods, thus enabling the shops to be always in full occupation. Students taking the five-year course are given an opportunity of passing through all the departments of the works, including the drawing office, and costing and estimating departments. The theoretical work of the various courses we need not enumerate in detail, they cover a line of study the main features of which will be familiar to our readers. In general the courses of engineering training fall into four distinct groups—mechanical, automobile and electrical engineering and chemical technology; the mechanical engineering course, for instance, is concerned in the main with the strength of materials, hydraulics and heat engines. The former of these leads up to structures and machine design, while the latter in the extended course allows of specialisation in internal-combustion work. A full engineering course naturally includes work in mathematics, chemistry, physics, &c., but apart from such portions of these subjects as necessarily accompany an engineering training, complete courses in pure mathematics and science for the degrees of the University of London are provided for students who wish to confine themselves to these branches of work.

It is, we understand, hoped and intended that the college shall become a centre for the training of chemical engineers, but it will be clear that at present its main equipment lies in the direction of the training of mechanical engineers. In the direction of internal-combustion engineering training in particular, the college occupies a very favourable place, by virtue of its heat engine testing and research laboratories. These laboratories were erected during the war in connection with aero-engine research, and also, as we have already said in connection with the training of aero-engine testers. They remain now as an important item in the college equipment. We give various illustrations of these laboratories in Figs. 20 to 28, on page 233, the present page, and page 235. The research laboratory is shown in Figs. 20 and 28, while the testing laboratory is shown in Fig. 20 and part of its equipment in Figs. 21 and 22. These laboratories are under the control of Mr. W. P. Johnson, A.R.C.Sc. (Lond.), A.M.Inst.C.E., and, in conjunction with Mr. Schofield, the principal, valuable research work was carried out during the war in connection with aero-engine performance. The work was done under the auspices of the Air Ministry.

The erection and equipment of the research laboratory was completed early in 1916, and work was at once undertaken with a view to perfecting apparatus for the accurate determination of both indicated and brake horse-powers. Shortly after the work was started, however, the demand for engine testers from firms engaged on aero-engine production became so great that it was decided to postpone the research work in order that the testing sets might become available for training purposes. A number of testers were trained, but the demand became increasingly acute, and it was decided to lay down a second laboratory mainly for training purposes. This second laboratory is the larger of the two, and is now known as the heat engine laboratory. The department was designed to accommodate 10 testing sets, five with engines of the rotary type and five with stationary engines. The original intention was to instal engines of as varied types as possible but, at the request of the Air Ministry, arrangements were made for equipping all the stationary sets with Sunbeam Coatalen 210-h.p. Arab engines. These engines were all to be coupled to Heenan and Froude brakes through flexible couplings, and were to be started by electric motors operating through spur gearing with an automatic cut-out. Before the completion of the equipment of this laboratory, work was suspended owing to the signing of the armistice, and subsequently the equipment was modified to render the building suitable for the heat engine laboratory of the Engineering College.

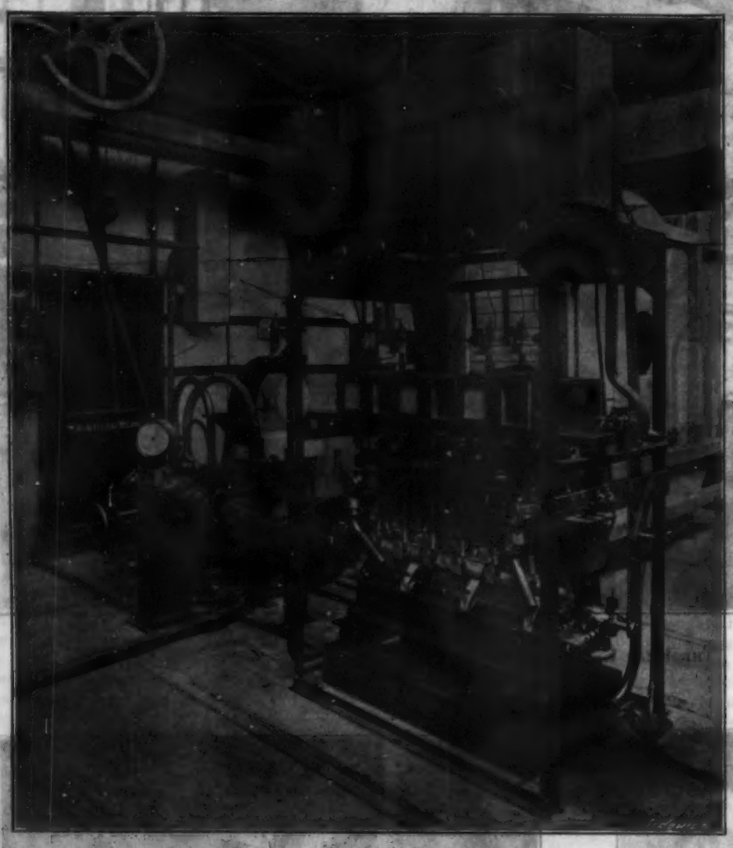


Fig. 23. Aero Engine with Indicators for Simultaneous Diagrams.

A good general view of the laboratory is given in Fig. 20, on page 233. The equipment now consists of five of the original Heenan and Froude brakes coupled to various types of stationary aero-engine, one rotary engine mounted on a balanced cradle and running in an escargot, and a number of car-engine testing sets of various types. The rotary engine is an 80-h.p. Le Rhone set. Two views of it are given in Figs. 21 and 22, on page 233. A 300 h.p. Dragon-Fly radial engine has recently been purchased and is being mounted on a second balanced cradle. This engine will be fitted with an ordinary propeller to produce the necessary cooling blast. The laboratory is provided with a self-contained water system for the Froude brakes, the water used being returned to an overhead tank by a Gwynne centrifugal pump electrically driven. The equipment also includes a 1,200 gallon underground petrol storage installation by the Steel Barrel Company, of Uxbridge. All piping arrangements are carried out in trenches, which latter also serve to carry off all surface water.

As soon as the new laboratory was sufficiently advanced to allow the work of training engine testers to be transferred to it, the research work was resumed in the original laboratory. The researches which have been, and are being, carried out have been directed to the accurate determination of brake horse-power and the investigation of the problem of indicating aero-engines. In connection with the former of the two researches an electric cradle dynamometer was designed by the college staff and constructed in the college workshops. This appliance, which is capable of dealing with engines up to 350 h.p., is of considerable interest, and we give a general view of it in Fig. 28, on page 235, and outline drawings in Figs. 24 to 27, on the same page. The dynamometer consists essentially of a deep box girder mounted on knife-edges. The girder carries two 440-volt dynamos specially built for the purpose by the Brush Electrical Engineering Company. The machines are direct coupled, and the connections are so arranged that the dynamos may be used either singly or in series according to the horse-power of the engine under test. The current from the machines is absorbed by liquid resistance tanks on the roof of the laboratory, the movement of the plates being controlled by means of a winch fixed near the end of the dynamometer.

The torque produced by the running engine is balanced by weights which are arranged to slide along projecting arms. A very accurate measurement is possible. The purpose of the dynamos is to furnish a convenient and easily-handled method of absorbing the power produced by the engine, and no electrical calculation enters into the determination of horse-power. As is best shown in Fig. 26, the dynamometer is arranged so that the weight of the cradle can be taken off the knife-edges when the apparatus is not in use. This is arranged for by means of toggle motions operated by long hand levers. The floating portion of the dynamometer weighs over 3 tons, and the maintenance of the knife-edges proved the most difficult problem in connection with the appliance. At certain engine

periods the cradle was found to be subject to considerable vibration with resultant wear on the knife edges. This had a pronounced effect on the sensitiveness of the instrument. After considerable experimental work, however, a steel was found from which knife-edges could be made, which gave the dynamometer an accuracy of 0.01 per cent. even after prolonged periods of running.

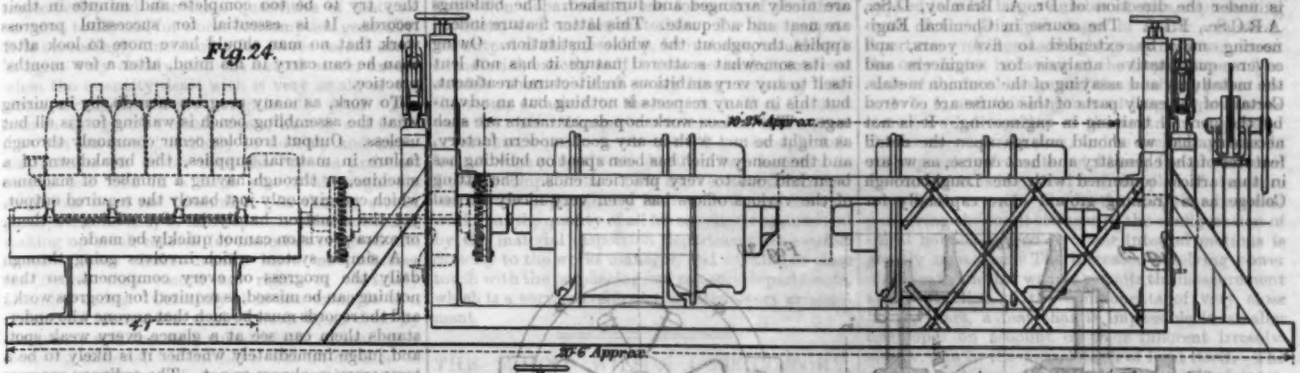


Fig. 24.

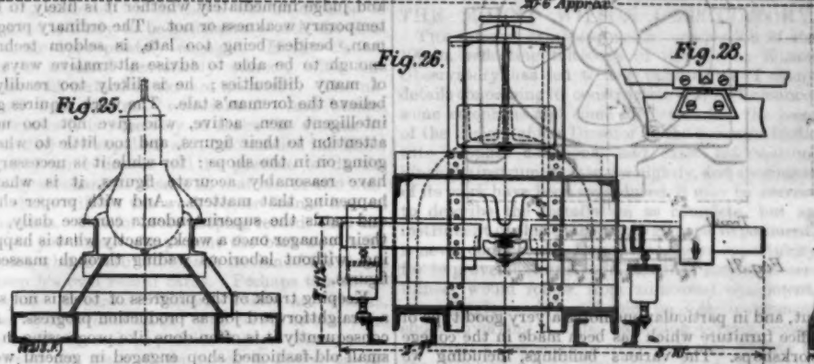


Fig. 25.

Fig. 26.

Fig. 28.

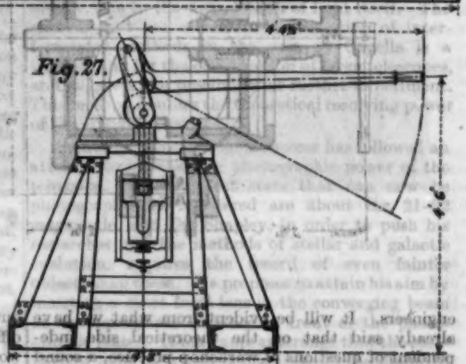


Fig. 27.

FIG. 28. CRADLE DYNAMOMETER.

The work which has been and is being carried out at the laboratory in connection with the indicating of internal-combustion engines has for its first object the obtaining of simultaneous diagrams from each cylinder of a multiple cylinder engine. It was thought that in this way much valuable information might be obtained in connection with the relative performance of the cylinders, and at the same time the mechanical efficiency be determined with great accuracy. The optical indicator designed by the late Professor Watson was selected for the tests, and a large amount of experimental work was carried out with a view to modifying the design to make it suitable for the small space available, the high explosion pressure used in aero-engine work, and the comparatively heavy vibration of the engines. As a result of this experimental work the design of the indicator was modified in all important particulars. The work ultimately resulted in arrangements by which simultaneous diagrams could be obtained at various loads. An engine equipped with the optical indicator outfit for obtaining simultaneous diagrams is illustrated in Fig. 23, on page 234. It is interesting to note that all the apparatus used, including the indicators, was manufactured in the college workshops.

In addition to the work dealt with above a considerable amount of other research was carried out on internal-combustion engines, especially in connection with the speed of flame propagation under various conditions. After the armistice, experimental work was also done, at the request of the Air Ministry, in connection with the utilisation of surplus aero-engines. This work led to the design of a very successful coal gas carburettor by Messrs. Schofield and Johnson. This carburettor is illustrated in Fig. 29 to 31, on page 236. As will be seen it consists of an outer casing formed with inlets for the gas and air and an outlet for the mixture. Inside the casing there is a drum-shaped liner, or sleeve, the angular position of which is controlled by a throttle lever. The rotation of the sleeve throttles the gas and air alike. Its total rotation is controlled by a stop at the back end of the carburettor. The special feature of the apparatus is that the air-gas ratio may be varied while running. This is brought about by moving the sleeve endwise. As will be seen, its longitudinal position in the casing is controlled by a knurled nut on the front end of the spindle and a helical spring which keeps this nut hard against the front end of the casing. Rotation of this nut consequently moves the sleeve endwise, and as will be seen the ports in the sleeve and the corresponding ports in the casing are so relatively placed that this endwise movement cuts off gas before cutting off air. An index on the front end of the spindle indicates the air-gas ratio given by various positions of the sleeve.

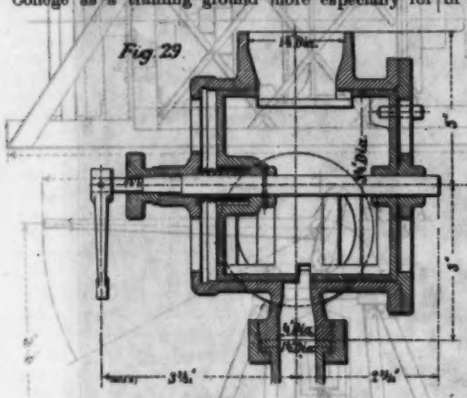
In addition to the departments we have already dealt with there is a fuel research laboratory, which is equipped for the investigation of the properties of liquid fuels and coal gas. The department is situated adjacent to the testing laboratory, as shown in Fig. 9 of our previous article. It is equipped with special apparatus for determining the calorific value of liquid fuel, Boys' and Simmance-Abady calorimeters and Macfarlane's apparatus for analysing exhaust gases. Alongside this laboratory there is a dark room. This West block also contains the heat-treatment laboratory, which is equipped with plant for the heat-treatment of both high-speed and carbon steel, case-hardening, tempering, &c. The various furnaces are by John Wright and Sons, with pyrometer equipment by the Cambridge Scientific Instrument Company. A research department connected with this laboratory contains a recalescence outfit and apparatus for the chemical analysis of iron and steel, and for the electrolytic separation and estimation of metals in various alloys. There is also a complete outfit for metallographic analysis, including a fine microscope and a duplex photo-micrographic camera, both by Messrs. W.

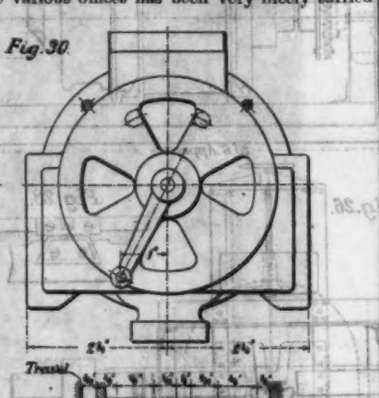
Watson and Sons, of London. There is also apparatus for measuring very small ranges of temperature, apparatus for the determination of the calorific value of solid, liquid and gaseous fuel, for the measurement of the pressures developed on the ignition of explosive gaseous mixtures, &c.

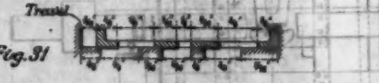
The Department of Chemical Technology, of which the heat-treatment laboratory forms a part, is under the direction of Dr. A. Bramley, D.Sc., A.R.C.Sc., F.I.C. The course in Chemical Engineering may be extended to five years, and covers quantitative analysis for engineers and the metallurgy and assaying of the common metals. Certain of the early parts of this course are covered by the general training in engineering. It is not necessary that we should enlarge upon the detail features of the chemistry and heat course, as we are in this article concerned with the Loughborough College as a training ground more especially for engineers. It will be evident from what we have already said that on the theoretical side independent of questions of workshop practice, a sound engineering education may be obtained at the college. Although we have not dwelt on them to any extent, all the usual college laboratories for mechanics, physics, &c., exist at Loughborough and supply the experimental work which is an essential feature of any adequate training in science. It is worthy of mention that the laboratories attached to the Mechanical Engineering Department include a special X-ray outfit supplied by the Cox Cavendish Electrical Co., Limited, for dealing with investigations in the structure of materials. This equipment comprises a 200,000 volt coil, with a Coolidge tube and localising table. In addition to the various buildings we have illustrated and described it is proposed to erect a South Block which will primarily be devoted to the electrical department, but will also cover further provision for the wood-working departments and the millwrights.

At the present time there are some 300 full time engineering students at the college, apart from trainees. Of this number about 200 are demobilised officers and other army men whose careers were interfered with by the war and who are taking advantage of the training scheme which is being administered by the Ministry of Labour. Ultimately, of course, this class must become extinct and the college must, to a large extent, depend on private students. It is encouraging from this point of view to see that there are already some 100 students of this class in what are yet the very early days of the Institution. Very complete arrangements have been made for the welfare of students and four large houses in the town have been taken and converted into hostels, each of which is under the charge of a matron. A College Union also caters for the students' welfare. This union has the use of reading and recreation rooms, and various sports clubs are run in connection with it. A playing field, covering 14 acres, has been acquired and is now being levelled and laid out for tennis, cricket, football and hockey, &c. A particularly fine pavilion is in course of erection. This scheme is typical of the foresight and wide outlook of the Governors of the College, over 8,000*l.* having already been spent on the purchase, levelling and equipment. In addition there is ample dining room and restaurant accommodation at the college, which is open until 9.30 p.m. These activities are under the direction of a lady supervisor who also controls the rest-room and surgery.

These various social departments of the college are nicely arranged and furnished. The buildings are neat and adequate. This latter feature indeed applies throughout the whole Institution. Owing to its somewhat scattered nature it has not lent itself to any very ambitious architectural treatment, but this in many respects is nothing but an advantage. The various workshop departments are such as might be met with in any good modern factory, and the money which has been spent on building has been laid out to very practical ends. The fitting of the various offices has been very nicely carried out, and in particular one notes a very good type of office furniture which has been made in the college workshops. The various buildings, including we believe the original central block, are to the design of Mr. E. T. Allcock, A.R.I.B.A., of Loughborough. In concluding this description we must thank the principal, Mr. Schofield, for facilities placed in our way in connection with its preparation, and also for attention at the time of our visit to the college. We must also thank Mr. W. P. Johnson, who conducted us over the various departments and supplied some of the information which we have utilised.







ARRANGING FUNCTIONS TO FIX RESPONSIBILITY.

By A. Whitehead.

(*Concluded from page* 206.)

Progress Department.—In a works arranged in the first way with one large machine shop, there are two principal ways of dividing up shop progress work. One is to attach each shop progress man or chaser to a certain shop or department, and for him to be responsible for progressing everything, whether belonging to A, B or C, passing through that department. The other way is for him to be given a specific group of components, and to follow this group through the works, wherever work is done on it. One objection is that in a large works the chasers can seldom be found. Although they have not perhaps many different subjects to keep in mind, a great deal of time is wasted in walking about, and saying "how do" to the many they meet. But when the works is sectionised, the advantages of both plans are realised, and the disadvantages of neither.

The progress man for the section A, for instance, will be engaged by the manager of A, and be responsible to him. He will watch outputs, keep records and charts, perhaps with the help of not more than a boy or young girl for clerical work. The daily outputs from the several processes must be watched very closely. There is no need to have the elaborate charts, sometimes coloured like the rainbow, which many progress men consider desirable.

In practice the whole history in the shops from receipt of material, placing of shop orders, daily progress, and delivery of the finished product, can be recorded on two charts, and two or three sets of cards. These will show the daily and weekly progress over a period of several months, in quite sufficient detail for all practical purposes.

The trouble with most progress systems is that they try to be too complete and minute in their records. It is essential for successful progress work that no man should have more to look after than he can carry in his mind, after a few months' practice.

To work, as many progress men do, by inquiring what the assembling bench is waiting for, is all but useless. Output troubles occur commonly through failure in material supplies, the breakdown of a machine, or through having a number of machines which can give only just barely the required output, yet the situation hardly justifies adding to them, or extra provision cannot quickly be made.

A simple system which involves going through daily the progress of every component, so that nothing can be missed, is required for progress work; and the records must be such that anyone who understands them can see at a glance every weak spot, and judge immediately whether it is likely to be a temporary weakness or not. The ordinary progress man, besides being too late, is seldom technical enough to be able to advise alternative ways out of many difficulties; he is likely too readily to believe the foreman's tale. The work requires good intelligent men, active, who give not too much attention to their figures, and too little to what is going on in the shops; for while it is necessary to have reasonably accurate figures, it is what is happening that matters. And with proper charts and cards the superintendents can see daily, and their manager once a week, exactly what is happening, without laborious wading through masses of figures.

Keeping track of the progress of tools is not such a straightforward job as production progress. And consequently it is often done like progressing in the small old-fashioned shop engaged in general work, and producing two or three of that, and a few of those, and so on; that is, no notice is taken of progress generally, except what the foreman notices and remembers.

A progress department can only justify itself by an increased output of the kind desired. Increased output is best obtained not by worrying or driving, but by providing plenty of work ahead, and proving whenever necessary (which with some foremen or superintendents is likely to be very frequently) that there is no difficulty in the way which a little ingenuity and determination will not remove.

Store-keeping.—The tool department should be run similarly to the production sections, and the chief requires a clerk to keep cards and charts adapted to show the tool progress in a convenient way. The charts should cover an extended period, three months is suitable, and should show every tool made or worked on during the period with the time spent every week upon it. Counterbores and tools of a like nature which are made perhaps by the gross, will be, of course, shown on the chart as one tool, but the total number dealt with stated.

Weekly charts are better than none at all, but it is far better to cover a longer period, so that a fair judgment can be formed quickly by glancing at what has been done during previous weeks. The charts indicate roughly whether or not any particular tool is receiving the desirable amount of attention, and give approximate means of roughly estimating the cost of the labour expended on each, which is near enough for many purposes.

Providing a suitable and simple system of recording the work given out, and booking the time on it is arranged in conjunction with the charts, there can be no job missed, except through clerical errors, and a fair idea of the progress made is easily gleaned by a glance. Repairs to tools must be controlled and provision made on the charts to show the expenditure thereon.

The tool stores in a works of this size must be split up, each part being under the control of the respective manager or other officer whom it principally

serves. They must maintain their own stock and therefore the keepers must be intelligent enough to anticipate roughly, future requirements as a check on, and to assist, the tool progress.

The general stores would be rather too large to be efficient, besides being inefficient geographically, if not divided up. Material has to be dealt with which is peculiar to the products A, B and C, respectively, and also large quantities of material common to all, and for works consumption generally. It is exceedingly uncommon for stores record cards to agree very closely with the actual stock, except when the quantity dealt with is very small, or the stores arrangements are exceptionally good. The man in charge of a small stores, having a definite job "on his own" is likely to develop and know his business far better than the man as assistant over a few bins in a large stores, although the conditions seem not dissimilar. In the big stores, perhaps at one end, or in a separate office, sit clerks making up stock records for materials received and issued. These clerks usually know not whether the figures they record are right, or obviously absurdly wrong. Certainly it is one example of a division of labour, the clerical work being done by one party, and the mechanical labour of issuing or receiving material by another; but no division of that kind is likely to be satisfactory with the class of labour appropriately engaged. If the clerical work is required reasonably correct, with this system well trained clerks are necessary. The untrained clerk has no "conscience." And besides good clerks it is necessary to make the system by which they are supplied with information infallible. Probably some day it will be possible to do the work by mechanical means, so that one or two well-paid clerks will do the work better than a host of cheap ones. But for store-keeping records that day has not yet come. At present the best way is for the man who superintends each section of the stores to keep his own record cards. Perhaps this seems to make dishonesty easier. There are checks, however, of several kinds. The best is to select the men carefully and pay them fairly. Since automatically the state of the stock is forced on the store-keepers' attention as records are made, there are good prospects that requisitions to maintain it will be issued in good time. But the assistant over a few bins, when he notices a bin nearly empty, what does he do? Or the clerk who keeps the records, even supposing his records are right and show that the particular material is nearly exhausted, what does he do?

Inspection.—In quick operations on small work frequent regular stoppage by the operator for gauging makes a big difference to the output, therefore it is sometimes held that the maximum output from the machines should be got and any errors discovered by viewers. But a little experience of this will convince anybody that the theory is false, and that any system which relieves the operator or setter, or charge hands of any responsibility whatever for satisfactory work is not economical. More production of course can be got, but much of it is certain to be not quite what is desired, even if not so bad that one has to scrap it. When much work comes through like this, and is brought into use by rectification, or adapting other parts to suit; the cost is sure to be extravagant; and much of the expense is of the kind which ordinary operation cost figures do not show.

Each charge hand must be definitely responsible for the quality of his own output, and must in turn hold his setters or operators responsible to him. Viewing is only a check. If looked at otherwise it tends to become production in disguise; and production which is extravagantly paid for as part of the indirect labour expenses.

In some ways it is attractive to have one chief inspector for the whole works under whom all viewers and inspectors serve. There must be a little give and take in all inspection, but it requires a thorough knowledge to make rapid decisions which are sound economically. How easy it is to suspend judgment indefinitely until lack of space to hold the work in detention compels a decision! If there were one chief inspector he would have to depend very much on at least three principal assistants, who, again, would be swayed by the sectional managers. How then can the chief inspector fairly be burdened with the responsibility? But if each sectional manager controls his own viewing a difficulty arises with inspecting raw material, the output of the press and automatic shops, and general stores.

We are led to the solution that there must be four inspection departments, one for each of the three products, and one for materials. For this purpose the output of the press shop, for instance, would rank as material, exactly as if it were received direct from outside sources. And everything entering into the stores attached to the section A, B or C, must pass the material inspectors once, unless it is a press or automatic product, when it will go through their hands twice; firstly as sheet or bar, secondly as finished components. Thus each sectional manager carries the responsibility for the quality of his own work, but the quality of all his supplies is maintained by the material inspection department responsible directly to the works manager, and working in close touch with the purchasing and research departments, which is a very convenient and satisfactory arrangement.

THE MOUNT WILSON OBSERVATORY.

The interest attaching to the completion of the 100-in. reflecting telescope of the Mount Wilson Observatory has led to the publication of many details concerning its construction and performance, some erroneous and some distorted, but the issue of the Report of the Director to the Carnegie Institute supplies additional and exact information. Since the instrument is in use nightly, and specimens of its work have been reproduced, it may be correct to describe the installation as complete, but an instrument of this character, a gigantic experiment, is never completed. Experience shows opportunity for improvement and indicates that increased usefulness would follow from additional equipment. Accordingly, work is still going on in the instrument shop, involving a tube balancing system, coudé mechanism, cage-clamps to give greater rigidity to the Newtonian and focal-plane cages, additional arrangements for controlling the temperature of the mirror, and numerous smaller devices that will enable the Observatory programme for investigation to be greatly extended.

In the preliminary tests some defects were noticeable which were perhaps exaggerated in the reports that reached this country. The principal of these had reference to the disappointing character of the star images. The causes that produced the imperfect images, though obscure and concealed, have now been traced to their origin and been remedied. They were three in number: (1) Imperfect adjustment of the edge support of the 100-in. mirror, now removed by relining the edge arcs and bringing their pressure to bear exactly in the correct plane; (2) occasional effects of coma and flare due to atmospheric disturbances near the telescope, especially the escape of warm air from the space behind the large mirror, when the cooling coils were not in operation, successfully overcome by circulating water of the right temperature through the coils, and entailing a complete automatic control system to maintain the mirror throughout the day and night at any desired temperature; (3) occasional atmospheric disturbances which produce an effect on the star images, closely resembling such astigmatism as might result from distortion of the large mirror. This annoyance will be felt only when photographing star fields at the 134-ft. focus, but the excellent images generally obtained with this great focal length give great satisfaction, and declare the superiority of the Hooker telescope over the 60-in. mirror in every class of work.

It may come as a disappointment to some to learn that the mammoth instrument will show stars only one magnitude fainter than can be seen with the 60-in. It may seem but a small return, for the expenditure of so much thought and energy, anxiety and outlay. But let it be remembered that theoretically no more could have been expected. The light-collecting power of the two instruments must vary as the square of the respective diameters, or, as 100 : 36, or approximately 2·8, and as the light of a star differs from that of a magnitude lower as 2·5 to 1, evidently one magnitude expresses the amount of the anticipated gain. But the grasp of one magnitude means the possibility of recording photographically many millions of stars too faint to be reached by the 60-in. mirror. Further, only a few stars could be studied with the most powerful spectograph of the 60-in., but in the larger telescope the same high dispersion can be applied to a far larger number of stars, representing most of the principal stages of stellar evolution. Aperture, with increased light grasping power, is not the only factor in favour of the large mirror. The scale of the focal image and the resolving power are as 1·7 : 1, and this longer focal length spreads the stars crowded together at the centre of a globular cluster over a larger area, and as each image stands out separately from its neighbour, the precision of measurement is increased and the plan of structure more easily traced. Evidently, too, the chance of perceiving the small changes in the configuration of spiral nebulæ caused by their internal motions is greatly increased. The increased resolving power operates in another way, it permits the measurement and separation of the components of very close binary stars, a feat that is impossible in smaller telescopes on account of their inherent irresolvability, due to the wave length of light itself. The success that has attended the adoption of interferometer methods in the case of Capella is a justification for the construction of large telescopes, and suggests the possibility of further experiment. This method doubles the theoretical resolving power of the Hooker telescope.

In another direction some success has followed an attempt to increase the photographic power of the telescope. The faintest stars that can now be photographically registered are about the 21–22 magnitude, and Dr. Shapley, in order to push his researches into the methods of stellar and galactic evolution, requires the record of even fainter objects than these. He proposes to attain his aim by inserting a short focal lens in the converging beam at an appropriate distance in front of the photographic plate. It may appear strange that the stoppage of light by a lens should increase the illumination, but the enhanced brightness is gained at the expense of the scale and the extent of the field. The effective focal length of the mirror is diminished, but with the same length of exposure fainter stars should be photographed. The apparatus is still under trial, but it is stated that a 3-minute photograph of the spiral nebula Messier 77 shows much fainter nebulosity than a 10-minutes' exposure without the lens intensifier.

The possession of enlarged optical means compels the adoption of a wider programme. The selection of these new fields of investigation, and the manner in which they will be occupied constitute the most interesting part of Professor Hale's report, for fresh possibilities of progress are indicated and new limits of attainment proposed. He shows how former work both in the Observatory and the Laboratory have led up to and rendered possible the fuller interpretation of celestial phenomena. A new epoch will now be entered upon, but there will be no breach with the old, the continuity of policy will remain unbroken, but extended. For instance, the long period variable stars, exhibiting the chemical characteristics of reduced temperatures, made familiar by the study of the vapours in Sun spots, presented problems that could be attacked in only a few isolated instances, but now these red and variable stars of various classes can be interrogated on a wide basis, both with reference to their place in the Galactic system and to their physical development. A still more fundamental problem arises in connection with the behaviour of rotating masses. Theoretical investigations have now reached a point where observations are necessary to assist discussion or to confirm deductions. Darwin and Roche, among others, have discussed the dynamics of particular cases of the problem, but in a form hardly realised in practice. Jeans, more recently, has dealt with the conditions actually encountered in stars and nebulæ. He finds that under certain probable conditions of density, a lens shaped figure having sharp edges will be produced. Matter thrown off at opposite points of the periphery should assume the form of two symmetrical filaments, which, if

sufficiently massive, will break up into nuclei, or diffuse away when gravitational attraction is small. Hence the necessity of a critical study of spiral nebulæ and binary systems. The preliminary results of observation on nebulæ are in harmony with Jeans' predictions, but in order to secure a definitive answer, a long photographic campaign involving the observation of spiral nebulæ of various types must be carefully organized and strenuously pursued.

Another great outlying question whose settlement demands the largest possible optical means concerns the position of the spiral nebulæ in stellar space. Are these bodies complete organisations, "island" universes in remote space, independent of one another and of our own Galactic system, or are they lesser systems, tributary to the Galaxy, which dominates the whole universe of stars? To advance into this problem the measurement of radial velocities with the most efficient spectroscope is necessary, and numerous parallaxes must be determined by a variety of methods. To measure the radial velocities of the smaller spirals is only possible with the Hooker instrument used to its utmost capacity. Such a programme is admittedly large and ambitious, but is far from being exhausted. It will become much larger under successful prosecution, for every problem will entail side issues and further inquiries. It may be that the method of final solution will differ widely from that contemplated in the original scheme. We heartily congratulate Professor Hale and his staff on what has been already achieved, making possible these more extended inquiries, and trust that they may see the accomplishment of the great task they have sketched with so much ability and are pursuing with such ardour.

THE AIRCO 18 AEROPLANE.

CONSTRUCTED BY THE AIRCRAFT MANUFACTURING COMPANY, LIMITED, HENDON, LONDON.

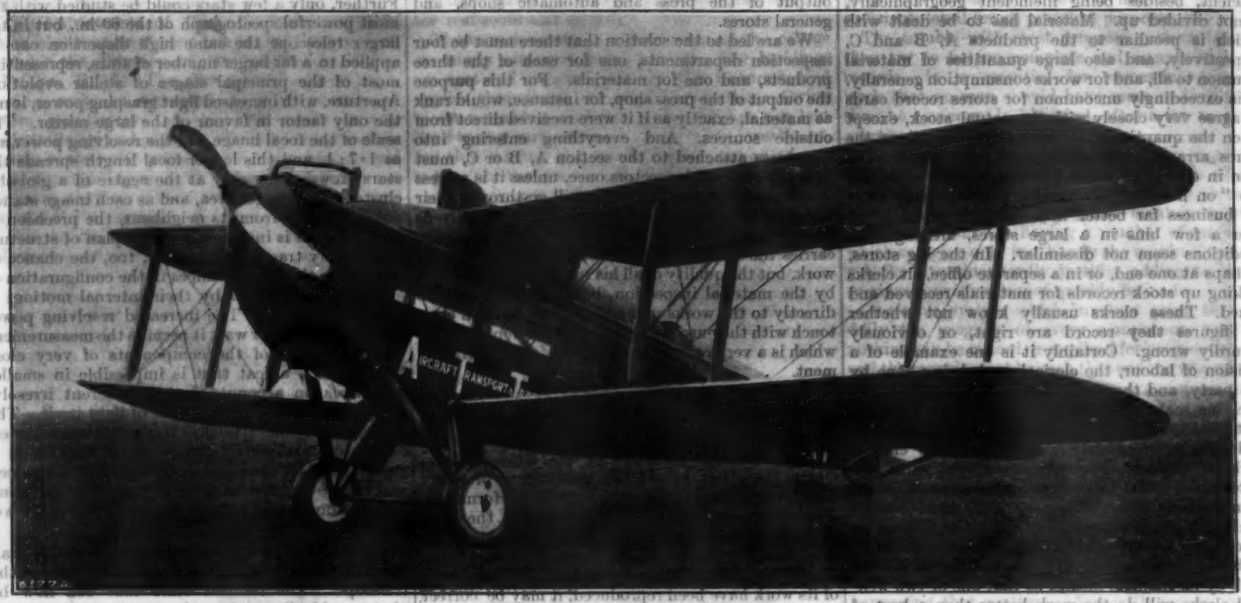


Fig. 1.

Fig. 2.

Very few of the commercial aeroplanes at present in service have been entirely designed for the work of carrying passengers or goods, the majority of them having been converted from models originally intended for bomb-dropping work in the war. Some of these converted machines have certainly put up very good performances on commercial work, since the requirements for the latter service have many points in common with those for bombing work, but their designers would probably admit that even better results might have been obtained had the machines been designed throughout with a full knowledge of the exact conditions under which they would be employed.

One of the notable exceptions to the above-mentioned rule is, however, the Airco (or D.H.) 18 aeroplane, which has been expressly designed by the Aircraft Manufacturing Company, Limited, of Hendon, for the passenger and goods carrying service operated by Aircraft Transport and Travel, Limited, between London and Paris and London and Amsterdam. Two of these machines have already been put into service on these routes with highly satisfactory results, and others are now under construction, so that the drawings and photographs of the machine reproduced on the present and opposite pages, and also on Plate XXV, which accompanies this issue, will be examined with interest. The machine is capable of carrying eight passengers in addition to the pilot, and from 200 lb. to 500 lb. of luggage, or, if used for goods transport only, a load of 2,240 lb. can be carried in a space of 255 cub. ft. Its weight fully loaded with pilot, passengers, 200 lb. of luggage and full tanks, amounts to 6,730 lb., made up as shown in the table accompanying Fig. 5, and with this load the speed attained on actual trial was 121 m.p.h. at 5,000 ft. and 118 m.p.h. at 10,000 ft. The time taken to climb to 5,000 ft. was 8¼ minutes and to 10,000 ft., 20¼ minutes, while the absolute ceiling is 16,000 ft. The machine is fitted with a 450-h.p. Napier engine which actually gives 500 h.p. at 2,200 r.p.m., and drives a two-bladed propeller through gearing at 1,400 r.p.m.; on later machines it is probable that three-bladed propellers will be used. The petrol consumption of the engine is 32 gallons per hour, and as the tanks are capable of holding 105 gallons, the endurance works out at 3·28 hours, or 395 miles. When carrying 1 ton of goods, without passengers, the total weight of the machine amounts to 7,450 lb., and the speed at 5,000 ft. under these conditions is 110 m.p.h.; the climb to 5,000 ft. takes 10 minutes.

It may be interesting to compare the performance of the Airco 18 aeroplane, in the matter of fuel consump-

THE AIRCO 18 AEROPLANE.

CONSTRUCTED BY THE AIRCRAFT MANUFACTURING COMPANY, LTD., HENDON, LONDON.

Fig. 3.

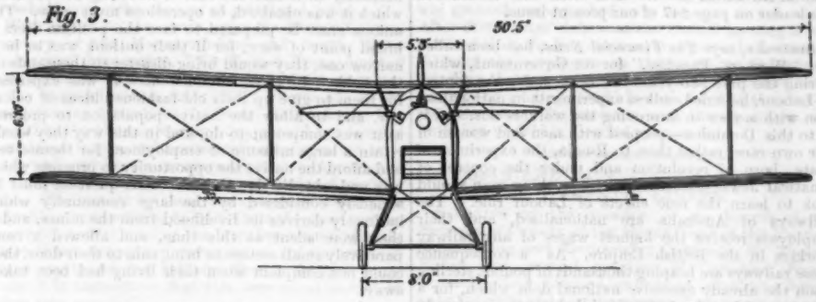


Fig. 4.

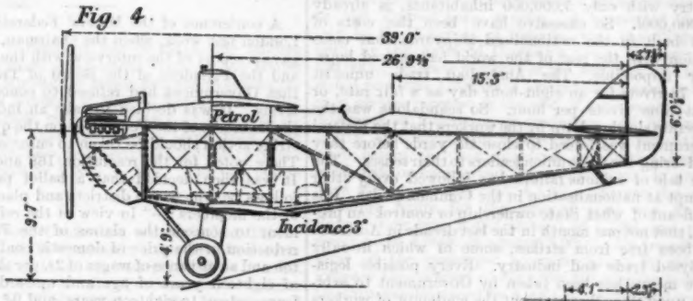
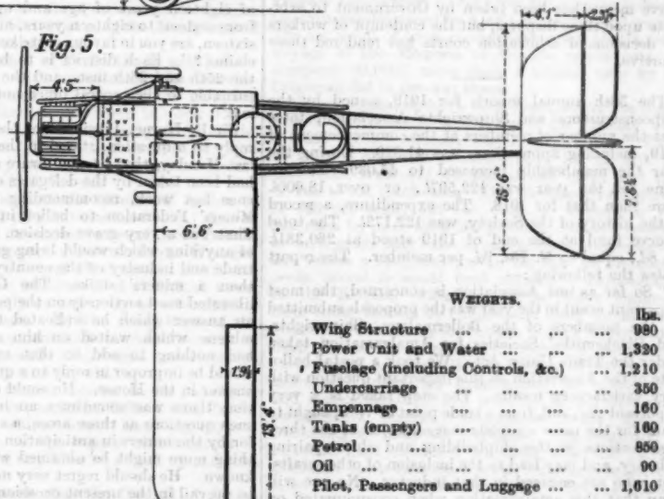


Fig. 5.



(6214.A)

WEIGHTS.

	lbs.
Wing Structure	980
Power Unit and Water	1,320
Fuselage (including Controls, &c.) ...	1,210
Undercarriage	350
Empennage	160
Tanks (empty)	160
Petrol	850
Oil	90
Pilot, Passengers and Luggage	1,610
Total	6,730

tion, with other forms of transport using petrol, though we are, of course, aware that fuel is not the only consideration in running costs. For passenger transport the Airco 18 gives 2·5 passenger miles at 121 m.p.h. for each 10,000 British thermal units in the fuel, whereas the best performance for a motor omnibus is 19 passenger miles at 8 m.p.h. for the same consumption of fuel. The disparity is, however, considerably less when carrying goods, the figures for the aeroplane and motor omnibus being 0·28 ton-miles and 1½ ton-miles respectively, per 10,000 British thermal units, at the speeds previously mentioned. The actual average performance of four motor lorries used by the Aircraft Manufacturing Company was found to be only 0·5 ton-miles per 10,000 British thermal units, at an average speed of 8 m.p.h., so that, if these figures are correct, it would be possible to transport a given amount of goods by aeroplane in one-fifteenth the time taken by a motor lorry for the expenditure of about 80 per cent. more petrol. The comparison is, however, admittedly unfair to the lorry, since it assumes a full load for the aeroplane and an average load for the lorry, but it serves to show that, as far as fuel consumption is concerned, the difference between the two methods of transport is not as great as is usually supposed.

The general appearance of the machine is well shown by the photograph reproduced in Fig. 1, on page 238, while a view of the interior of the cabin is given in Fig. 2 on the same page. As will be seen from the latter illustration, the cabin is provided with four single-backed seats with a double seat at each end; the former, it will be noticed, are arranged to face in opposite directions in order to facilitate the movements of passengers. The seats are comfortably upholstered, and the walls of the cabin are covered with similar fabric. Three large windows of "Triplex" glass, which can be opened by sliding horizontally, are provided on each side of the cabin, so that passengers have a good view of the country over which they are travelling. This is an important desideratum, as it adds materially to the pleasure of an aerial journey. The inside dimensions of the cabin are 11 ft. long, 4 ft. 5 in. high and 3 ft. 8 in. wide.

The main dimensions of the machine are given on the general arrangement drawings, Figs. 3 to 5, annexed, from which it will be seen that the overall length is 39 ft., while the span of the wings is 50 ft. 5 in. The gap between the wings is 6 ft. 10 in., and the chord is 6 ft. 6 in. This gives a total wing area of 618 sq. ft., so that, taking the total weight as 6,730 lb., the wing loading works out at 10·9 lb. per square foot; for the same total weight, the weight per horse power is 13·45 lb. The wing structure calls for no special comment, except that it should be mentioned that the wings were, in the first design, arranged to fold back about the rear struts of the centre section; in later machines this has not been done. They are set for a normal incidence of 3 deg., and there is a dihedral angle of 3 deg., on each side, as shown in Fig. 3. The wing section is a slightly modified form of R.A.F. 15, and the main spars are of laminated construction and of I-section.

The fuselage, broadly speaking, is also constructed in accordance with generally accepted practice, the struts and longerons being of spruce connected by the usual steel plate sockets and braced with swaged steel wire. Its length is divided into eight bays, each 3 ft. 7½ in. long, of which the first three form the passenger cabin, while the fourth contains the pilot's cockpit. Behind this is a bay used for additional passengers' luggage. The cabin is of watertight construction, and the sides and bottom of the luggage compartment are covered with three-ply wood to give buoyancy for the purpose of keeping the machine afloat in the event of a forced descent into the sea. Additional buoyancy is provided by flotation bags fitted in the bays behind the luggage compartment. The construction of the first four bays of the fuselage is well shown in the drawings reproduced in Figs. 6 to 10, on Plate XXV, which drawings are practically self-explanatory. It will be noticed that the cabin floor is supported by longitudinal bearers of the form shown dotted in Fig. 6, a line of bearers being placed on each side of the centre line as shown in the plan, Fig. 7. Diaphragm bracing is, of course, omitted between the three bays forming the cabin, and the side bracing is also omitted from the third bay on the port side to provide a clear opening for the door giving access to the cabin. This bracing is replaced by a diagonal strut extending from the top of the third vertical strut to the bottom of the fifth vertical strut as shown in Fig. 6. A circular hole, normally covered with non-inflammable celluloid, is provided in the roof of the cabin as shown in the half-tone engraving, Fig. 2, on page 238. This was intended for loading the machine when carrying goods, but it also provides an exit for the passengers in case of emergency.

An interesting feature in the design of the machine, and one which is of considerable importance to a commercial aviation concern, is the arrangement of the engine mounting which permits the whole power unit to be easily detached and replaced by another in a few minutes. The importance of this feature lies in the fact that the greater part of the troubles experienced with aircraft occur in connection with the power unit, so that, if the later can be quickly replaced by a spare set, the machine can spend considerably more time in the air than would otherwise be the case. Drawings of the complete engine mounting are reproduced in Figs. 11, 12 and 13, on Plate XXV, Fig. 11 being a side elevation, Fig. 12 giving half elevations from the back and front ends, and Fig. 13 being a half plan. The engine bearers, it will be seen, are supported at the rear by a horizontal transverse member carried by a rectangular framework, while the front ends are supported by members sloping from the corners of the rectangular frame, as is most clearly shown in Fig. 11. The front ends of the bearers are stiffened by a perforated plywood connection dipped as shown in Fig. 12 to clear the engine crank-case. The whole mounting is attached to the front of the fuselage by four bolts, and, to detach the power unit, it is only necessary to remove these bolts, disconnect the petrol pipe by means of a union, and uncouple the controls, which are conveniently arranged on a rocker arm to facilitate this operation. The oil tank, radiator and water-header tanks are carried on the engine mounting, so that the oil and water connections need not be broken.

The engine casing, which is of sheet aluminium, is carried by light channels of the same material. Its shape, and the method of securing it, can be followed from the drawings reproduced in Figs. 14 to 17. The radiator is of the usual honeycomb type, and it is placed under the engine at an angle of 30 deg. with the vertical. Air reaches the radiator through adjustable louvres, and, after passing through the radiator, escapes through an opening in the bottom of the casing. These louvres can be distinguished under the propeller in the half-tone engraving, Fig. 1, on page 238, and their construction is clearly shown in Figs. 18, 19 and 20, on Plate XXV. The arrangement gives the pilot complete control of the temperature of the cooling water.

Figs. 21 and 22 show the general arrangement of the under carriage, the wheels of which are arranged to give a track 8 ft. 3 in. wide. The tyres are of the Palmer cord type, 900 mm. in diameter with 200-mm. treads. The axle, which is of high tensile steel tube, is supported mainly by two shock absorbers of the combined rubber and "Oleo" type, but its longitudinal movement is restricted by two radius rods connected to the fuselage as shown. Detail drawings of the connection of the radius rod, shock absorber strut, and axle are reproduced in Figs. 23 and 24, while Figs. 25 to 27 illustrate the construction of one of the shock absorbers. These comprise three steel tubes, one of which is pivoted to the axle, while the other two are connected to the fuselage by means of the ball and socket joint shown. The central tube in Fig. 26, which is pivoted to the axle, passes through a crosshead

fixed to the lower ends of the other two tubes, and carries at its upper end a similar crosshead. The upper crosshead slides on the two tubes, as will be understood from the drawings, and is connected to the lower crosshead by 18 separate loops of braided rubber, which are enclosed in a stream line fairing to reduce air resistance. Upward movement of the central tube is thus resisted by the extension of the rubber loops. Referring again to Fig. 26, it will be noticed that the central tube is fitted with a stationary piston, which is mounted on a tube passing through a packed gland in the upper crosshead and terminating in the ball of the ball and socket joint by which the shock absorber is attached to the fuselage. The central tube is filled with oil which passes freely through a valve in the piston during the upward movement of the tube. The tendency of the rubber loops is, of course, to restore the central tube to its original position, but this action is delayed by the closing of the valve in the piston. The oil then flows from the upper end to the lower end through a small opening controlled by a spring-loaded mushroom valve, which is set to open at a pressure of 500 lb. per square inch. The central tube, and with it, of course, the wheels and axle, thus moves downwards gradually, and all tendency of the machine to "bounce" is avoided.

The arrangement of the empennage, which is of the monoplane type, is shown in Figs. 4 and 5, which also give the main dimensions. The rudder, it will be noticed, is aerodynamically balanced, the balance area being 1·67 sq. ft. and the total area 18 sq. ft. The area of the vertical fin is 6·36 sq. ft. The span of the tail plane is 15 ft. 6 in., and the chord is 4 ft. 1 in., while the chord of the elevators is 2 ft. 3½ in. This gives an area of 56 sq. ft. for the tail plane and 24·2 sq. ft. for the two elevators. The latter, as will be seen, are not balanced aerodynamically, but a simple mechanical device is included to reduce the effort required to operate them. A somewhat similar balancing arrangement is provided in connection with the wing ailerons, four of which are fitted. Each aileron has a span of 13 ft. 4 in., a chord of 1 ft. 9½ in., and an area of 23 sq. ft. The tail skid is of the steerable type and is constructed of steel strips in the form of a leaf spring. It has four laminations, the longest of which is bent round and fitted at its lower end with a detachable shoe shaped like a spoon to prevent any tendency to dig into the ground. It may here be mentioned, although the fact will probably have been noticed from an inspection of Fig. 4, that, when the wheels and tail skid of the machine are both in contact with the ground, the angle of incidence of the wings is greater than usual. The actual incidence is then 18 deg., at which angle the wing resistance is sufficient of bring the machine to rest rapidly.

The only other point which need be referred to to complete our description of the machine, is the means provided for warming the passenger cabin. It will be noticed in the half-tone engraving, Fig. 1, on page 238, and from the plan view, Fig. 5, on page 239, that the engine exhaust pipes run along on both sides of the fuselage near the top of the cabin. These pipes are fitted with sleeves open at the forward ends and connected, at their after ends, to the interior of the cabin. Air entering the sleeves is thus heated by contact with the hot exhaust pipes and delivered into the cabin at a suitable temperature. Sliding grids are fitted in the cabin for regulating the quantity of warm air delivered.

In conclusion we may mention some of the reasons which influenced the decision of the firm to design, for commercial service, a machine of the size and type of the Airco 18. If the machine is much smaller, they point out, the weight of the pilot becomes too great a proportion of the total load, and, if the size is increased, the weight of the structure tends to increase at a more rapid rate, again reducing the proportion of the useful load. They also consider it better, for commercial purposes, to divide a very large twin-engined machine into two smaller machines with separate engines, except for the fact that a pilot is then required for each machine. The cost of the additional pilot, however, they regard as negligible in comparison with the increased earning power of the two machines. There is, of course, room for more than one opinion on this point, but it must be remembered that comparisons are of little use unless the machines compared possess the same true maximum speed.

Foreign Contracts.—We are informed by the Department of Overseas Trade that the Commercial Counsellor to H.M.'s Embassy at Rome reports that a large firm of Italian manufacturers of explosives are reorganising their works in order to produce coal and benzol sub-products, including phenol, saccharine, dyes, chemical manure, synthetic carbolic acid, films, &c. The firm in question are anxious if possible to place their orders in this country, and would be glad to receive catalogues and price lists of plant suitable for the products. Further particulars may be obtained from the Comptroller-General of the Department of Overseas Trade, Old Queen-street, S.W.1.

INDUSTRIAL NOTES.

The Unemployment Insurance Act, which received the Royal Assent on the 9th inst., will come into operation on November 8. We deal with this measure in our leader on page 247 of our present issue.

Australia, says *The Financial News*, has been called the "Workers' Paradise," for its Government, which during the past two years has been under the control of Labour, has tried endless experiments in nationalisation with a view to improving the workers' lot, and it is to this Dominion—peopled with men and women of our own race, rather than to Russia, the experimental State, born of revolution and under the control of fanatical Jews—that the British working man should look to learn the true effects of Labour rule. The railways of Australia are nationalised, and their employees receive the highest wages of any railway workers in the British Empire. As a consequence these railways are heaping thousands of pounds sterling upon the already excessive national debt which, for a country with only 5,000,000 inhabitants, is already 750,000,000*l*. So excessive have been the costs of ships built in the nationalised shipyards that competition with the rest of the world has proved hopelessly impossible. The Australian trade unionist fixes 73 rivets for an eight-hour day as a fair rate, or about nine rivets per hour. So scandalous was the deliberate slowing down by the workers that the Federal Government was forced to close the yards before they could bring the trade union leaders to their senses. The same tale of ruinous failure has followed every other attempt at nationalisation in the Commonwealth. It is significant of what State ownership or control can produce, that not one month in the last decade in Australia has been free from strikes, some of which literally paralysed trade and industry. Every possible legislative means has been taken by Government to arbitrate upon these disputes, but the contempt of workers for decisions of arbitration courts has rendered these abortive.

The 38th annual report, for 1919, issued by the Shipconstructors' and Shipwrights' Association, states that the number of members at the commencement of 1919, including apprentices, was 41,329. During the year the membership increased to 45,039. The income for the year was 122,597*l*., or over 18,000*l*. more than that for 1918. The expenditure, a record in the history of the Society, was 122,172*l*. The total reserve fund at the end of 1919 stood at 260,381*l*. 7*s*. 8*d*., equal to 5*l*. 15*s*. 9*d*. per member. The report states the following:—

"So far as our Association is concerned, the most important event in the year was the proposals submitted to the members of the Boilermakers, Shipwrights, and Blacksmiths' Societies for Amalgamation taken under the Trade Union Act. We took a postal ballot vote of the Association on this important question with very satisfactory results. The step taken is a very important one, and, from a trade point of view, ought to make for the more complete consolidation of the three organisations in the shipbuilding and ship-repairing industry, and may lead to the inclusion of other craftsmen who are engaged in that industry. No one will deny that this amalgamation when consummated on equitable lines, will, from the trade's standpoint, be of benefit to all concerned. The employers are organising to-day more completely than ever, and to meet organised capital on anything like equal terms, there is no doubt trade organisations will have to come more closely together in the various industries in which they are engaged. Many difficulties will have to be overcome before the Amalgamation is consummated, but at the same time there is no reason why these initial difficulties cannot be surmounted, more especially if the members of the three organisations in the yards and shops co-operate with each other to strengthen their organisation and mutually assist each other in any difficulties which may arise from time to time."

According to the South African Mining and Engineering Journal, Mr. J. Whitehouse, the newly-elected President of the South African Institution of Engineers, in his inaugural address said he would invite workmen employed on the South African fields to strive to attain that efficiency which alone could prove effective in these difficult times. The necessity for great effort on the part of the employees of the fields was, he ventured to say, fully realised by their leaders, and one could only hope that their followers would be guided by their advice. The enforced closing down of some of the low-grade mines will have demonstrated that the mysterious source of wealth which many had imagined to exist, but the origin of which they had not troubled to investigate, was nothing more than the result of the work performed by all in their particular industry, and that, in common with undertakings all over the world, it was necessary to obtain at least the equivalent of the money spent in any business to justify its continued operation. This being so, it was clear that as the production of gold from the lower grade mines became less, it would be necessary to reduce the cost of handling the ore from which it was obtained, or operations must cease. The unions must be prepared to face the position from a broad point of view, for if their outlook was to be a narrow one, they would bring disaster to thousands on the fields. In these circumstances it was expedient for them to give up their old-fashioned ideas of colour bar, and to allow the native population to progress as it was competent to do, and in this way they would retain a large measure of employment for themselves, and afford the native the opportunity to progress which was undoubtedly due to him. This question must be seriously considered by the large community which indirectly derives its livelihood from the mines, and if they were silent at this time, and allowed a comparatively small section to bring ruin to their door, they could not complain when their living had been taken away.

A conference of the Miners' Federation was held in London last week, when the chairman, Mr. R. Smillie, gave a report of the interview with the Coal Controller and the President of the Board of Trade, and stated that Government had refused to concede the miners' terms. It was decided to take an individual vote of the members of the Federation on the question whether strike action should be taken to enforce the said terms. There voted for the resolution 168 and three against. It was then decided that a ballot paper worded as follows be sent to the districts and placed in the hands of the members:—"In view of the refusal of Government to concede the claims of the Federation for a reduction in the price of domestic coal by 14*s*. 2*d*. per ton and an advance of wages of 2*s*. per shift for members of eighteen years of age and upwards, 1*s*. per shift from sixteen to eighteen years, and 9*d*. per shift below sixteen, are you in favour of strike action to secure these claims?" Each district is to ballot its members on the 25th and 26th inst., and the ballot papers are returnable to the central office not later than the 30th inst.

Sir R. Horne, President of the Board of Trade, in reply to a question, stated in the House of Commons, last Monday, that he was aware of the decision which had been taken by the delegates of the Miners' Conference last week, recommending the members of the Miners' Federation to ballot in favour of a strike. That was a very grave decision. He could not think of anything which would bring greater disaster on the trade and industry ot the country at the present time than a miners' strike. The Government had deliberated most anxiously on the position, and had given an answer which he indicated to the deputation of miners which waited on him some days ago. He had nothing to add to that answer. Obviously it would be improper in reply to a question to discuss that answer in the House. He could only say, in addition, that there was sometimes an impression that when such questions as those arose, a strike should be voted for by the miners in anticipation that thereafter something more might be obtained when the decision was known. He should regret very much if that view were to prevail in the present occasion, and he hoped wiser council would obtain. (In meeting the deputation referred to, Sir Robert stated that the dispute was not one between the miners and their employers, but between the miners' leaders and the State; he enumerated the advances the miners had received in their wages; any profit which the country is making, he added, is derived from exported coal, and, if the miner is entitled to claim this, the textile operative and steel worker will in like degree be entitled to demand that the sums of excess profits duty which his industry pays to the State be applied to his benefit in increased wages. Such a demand cannot fairly be conceded, and a strike to attempt to enforce it is an injustice to the whole body of our citizens.)

In a written reply to Mr. Hancock, Sir Robert Horne has stated that the average wage of adult male colliery works is now 157 per cent. above the pre-war level. Up to September, 1917, the dates and amounts of increases in the wages of colliery workers varied in the different districts. The general result was to advance the average wage of adult male colliery workers by about 50 per cent. above the pre-war level. Since that time the following general increases have been given:—

September 17, 1917	1*s*. 6*d*. a shift ("war wage").
June 1, 1918	1*s*. 6*d*. a shift ("war wage").
January 9, 1919	2*s*. a shift ("Sankey wage").
March 12, 1920	20 per cent. on gross earnings exclusive of "war wage" and "Sankey wage," with a minimum of 2*s*. a shift.

The percentage increase in the general cost of living

over the same period is estimated by the Ministry of Labour to be 152. This figure is based on working-class family expenditure on food, rent, clothing, fuel, &c., according to their relative importance before the war, and the great majority of coal miners get their household coal either free or at privileged prices.

With regard to the above, says Mr. Finlay Gibson, secretary of the Monmouthshire and South Wales Coalowners' Association, "Sir Robert Horne omitted one important fact in his statement of the increases in the wages of miners since 1917. It was one of the conditions as a result of the Seven Hours Act of last year that the shorter working day should not involve diminished wages, and accordingly arrangements were made under which the earnings of piece-workers should be increased by 14·2 per cent. for the reduced working time. The miners by these arrangements obtained so valuable a concession as to leave them the same earning power for a working day one hour less than under the Eight Hours Act, and in any statement of the course of wages in the mining industry during the past three years it is imperative that this concession should be taken into account."

Speaking in Parliament last Monday, Sir Robert Horne said the main amendment made in the House of Lords to the Ministry of Mines Bill was to substitute for the proposed Ministry of Mines a Department under the Board of Trade with a Secretary of Mines as its chief. He asked that the House agree with that amendment. He, also, proposed that the salary of the Secretary of Mines be 1,500*l.* a year. The two points were agreed to.

A special Labour Conference was held last Friday at the Central Hall, Westminster, to receive the reports of the Council of Action. It was presided by Mr. W. Adamson, chairman of the Parliamentary Labour Party, and Mr. W. H. Hutchinson, of the Amalgamated Engineering Union moved :—

"That this Conference of Trade Union and Labour representatives hails with satisfaction the Russian Government's declaration in favour of the complete independence of Poland as set forth in their Peace Terms to Poland, and, realising the gravity of the international situation, pledges itself to resist any and every form of military and naval intervention against the Soviet Government of Russia.

"It accordingly instructs the Council of Action to remain in being until they have secured :—(1) An absolute guarantee that the armed forces of Great Britain shall not be used in support of Poland, Baron Wrangel, or any other military or naval effort against the Soviet Government. (2) The withdrawal of all British naval forces operating directly or indirectly as a blockading influence against Russia. (3) The recognition of the Russian Soviet Government and the establishment of unrestricted trading and commercial relationships between Great Britain and Russia.

"This conference further refuses to be associated with any Alliance between Great Britain and France or any other country which commits us to any support of Wrangel, Poland, or the supply of munitions or other war material for any form of attack upon Soviet Russia.

"The conference authorises the Council of Action to call for any and every form of withdrawal of Labour which circumstances may require to give effect to the foregoing policy, and calls upon every trade union official, executive committee, local council of action, and the membership in general to act swiftly, loyally, and courageously in order to sweep away secret bargaining and diplomacy and to assure that the foreign policy of Great Britain may be in accord with the well-known desires of the people for an end to war and the interminable threats of war."

The resolution was carried unanimously.

The Prime Minister, speaking on the question in Parliament last Monday, likened the Labour Conference decision to the "swinging of a sledge hammer at an open door, only intended for display." He added that "any attempt to dictate policy to the Government and Parliament by industrial action struck at the root of the democratic constitution of this country and would be resisted by all the resources of the Government."

The Negotiating Committee, representing the gas-workers of the country, met representatives of the Gas Employers' Federation in conference last Monday at the House of Commons. It was afterwards stated by Mr. Will Thorne, M.P., Secretary of the General Workers' Union, that the employers had definitely refused the claim for a further advance of 1*s.* per day for the gasworkers, and that the refusal would be reported to the national conference of the unions involved at Oxford on Wednesday. It was expected that the question of taking a strike ballot to enforce the demand would be considered, and the position was regarded as critical. The employers intimated that they were of opinion that their proposals in regard to grading and zoning would to a great extent remedy the grievances in various areas, but beyond that they declined to go, pointing out that a national settlement, under which an increase of 6*s.* was granted, was reached only a month or two ago." After three hours' debate at the Oxford meeting it was resolved that, the Negotiations Committee be instructed to meet the employers on this issue on the understanding that agreements reached in connection with zoning and grading should be completed at the earliest possible date. The meeting with the employers will probably be held in London next week.

COSTS AND RUNNING CHARGES OF ATLANTIC LINERS.

SPEAKING on the occasion of the launch of the Empress of Canada at the Govan Yard of the Fairfield Shipbuilding and Engineering Company, Sir Thomas Fisher, the general manager of Canadian Pacific Ocean Services, Limited, gave some interesting figures as to the costs and earning powers of passenger steamers on the Transatlantic service. A somewhat similar ship to the Empress of Canada, viz., the Calgarian, built by the Fairfield Company before the war, cost 550,000*l.*, whereas the cost of the Empress of Canada would be about 1,700,000*l.* There had, he said, been an even greater increase in the cost of maintenance. The difference in insurance, depreciation, and interest on capital on a ship built to-day, as compared with one built before the war, involved an additional charge of 20,000*l.* on each round Atlantic voyage. In pre-war days the round trip cost 4,500*l.*, whereas the corresponding figure for the present time was 24,000*l.* Repairs now cost 7,700*l.* instead of 1,700*l.* and provisioning cost 8,000*l.* as against 3,000*l.* By transferring some of the passenger accommodation in order to increase the comfort of the crew the earning power of the ship was decreased by 5,000*l.* for each round voyage. The net result of these circumstances was that a round voyage of the Empress of Canada would cost the company 60,000*l.* more than a similar trip by the Calgarian did in pre-war times.

Many complaints have been made about the higher cost of Transatlantic travel, but in Sir Thomas' view, a much greater increase was fully justified. Fares, he pointed out, had increased from 19*l.* to 50*l.* 10*s.* first class, from 11*l.* to 28*l.* second class, and from 6*l.* 10*s.* to 19*l.* third class. This represented an increase of 185 per cent., but the cost of working a ship had risen by more than 350 per cent. Such a position, he said, could only exist in exceptional circumstances, and unless a stop was put to the rise in the cost of ocean travel it would tend towards a disintegration of the Empire. There would be fewer emigrants from Great Britain to Canada and there would consequently be a tendency for Canada to draw its population from across the border. In order to render less extravagant rates possible he suggested the development of shipbuilding organisation by combination and standardisation, and possibly by a reduction in shipbuilders' profits. Shipowners could also do something to meet the situation. His company, for instance, had cancelled an order with the Fairfield Company for a first class ocean liner and substituted it by one for an intermediate liner. Great economies could be effected by employing a simpler class of vessel in place of the costlier ships formerly employed, especially in the matter of speed. By reducing the speed of an Atlantic liner by 4 knots, which would increase the length of the voyage by 24 hours over the time taken by a 20-knot boat, half the coal could be saved, and by employing internal-combustion engines the fuel costs would be again halved.

The Empress of Canada, which was launched on Tuesday last, will be propelled at a sea speed of 18 knots by double-reduction geared turbines of the Brown-Curtis type, driving twin screws and supplied with steam from oil-fired boilers. She is intended for service between Vancouver, Japan, China and Manila, and will be the largest mail and passenger steamer on the Pacific. The length of the ship is 653 ft., the breadth 77 ft. 9 in., the depth from bridge deck to keel 53 ft. 6 in., and the gross tonnage 22,000. Accommodation will be provided for 500 first class, 100 second class, 240 third class, and 930 Asiatic passengers, and a crew of about 550, so that the total number of persons carried will be 2,320. First class passengers will be accommodated on "B" deck in large state-rooms for two, three or four persons, and also in cabins on "C" deck. A number of private suites and special rooms are also provided. The first-class dining saloon is situated on "D" deck amidships and will seat 307 persons in groups of two, four or six round separate tables. Forward of the dining saloon is a large reception room with an oak parquet floor suitable for dancing. A special feature of the ship is a long gallery leading from the main stairway on "A" deck, and giving access to the principal first-class public rooms. This gallery is 110 ft. long and 13 ft. wide, and the sides will be panelled with polished Honduras mahogany. The first class lounge is situated at the forward end of the gallery, and at the after end is the smoking room, opening out of which is a verandah café. In addition to extensive promenading spaces, a swimming bath and gymnasium are provided for exercise and recreation. The second class accommodation is on the after part of "C" deck in staterooms for two or four persons. The dining saloon for second class passengers is on "D" deck and it is arranged to accommodate 100 persons. Third class passengers, who are berthed on "D" and "E" decks, also have a dining saloon on the after part of "D" deck, capable of seating 100 persons; Asiatic steerage passengers are accommodated in open berths in large compartments on "C," "D" and "E" decks. In designing the vessel the fact that she will serve in a semi-tropical climate has been borne in mind, and the public and private rooms have therefore been made large and airy; special attention has been given to the matter of ventilation of all parts of the ship. Mr. Hugh McDonald, the naval architect to Canadian Pacific Ocean Services, Limited, prepared the designs for the ship, which was built under the supervision of Messrs. J. H. Biles & Co.

After the launch of the Empress of Canada, another vessel belonging to Canadian Pacific Ocean Services, Limited, viz., the Empress of Britain, which has been reconditioned by the Fairfield Company after serving during the war as an armed cruiser and transport, was handed over to the owners. This vessel, which was built by the Fairfield Company in 1905, is propelled by twin-screw reciprocating engines, and the most important part of the work of reconditioning has been the fitting of an oil-fuel burning installation. The coal bunkers have been reconstructed for carrying oil, of which sufficient can be stored for the round voyage from Liverpool to Quebec. The Wallsend-Howden oil fuel system has been adopted with Dahl patent burners, and the fuel used is a heavy grade of Mexican oil. The boilers, which work under the Howden system of forced draught, and supply steam at 200 lb. per sq. in. pressure, are arranged in two separate boiler rooms, each of which has its own separate equipment of transfer pumps, heaters, and other accessories. The oil pipe lines have been arranged to facilitate the warming up of any, or all, of the boilers before starting, and special attention has been given to the lighting and ventilation of the boiler rooms, as well as to the matter of fire extinguishing. In addition to the structural alterations rendered necessary by the installation of the oil fuel system, new fireproof bulkheads have been fitted in the 'tween decks, new davits for the lifeboats have been provided, electrically-driven fans have been substituted for steam-driven fans to supply the forced draught, and large turbo generators have been installed to provide additional electric power. The passenger accommodation has also been completely remodelled.

Prior to the launch of the Empress of Canada, the Empress of Britain had carried out successful trials after being reconditioned, and, later in the day, the latter vessel proceeded round to the Mersey, where she arrived on Wednesday morning. Most of the guests present at the launch of the Empress of Canada were taken round to Liverpool on this trip. The Empress of Britain is employed on the Liverpool-Quebec service, and will sail from the former port on her first post-war voyage on September 1 next.

PRODUCTION OF PIG-IRON AND STEEL IN JULY.—The production of pig-iron in July amounted to 750,400 tons (the highest monthly total attained since the armistice) and of steel ingots and castings to 800,100 tons. The pig-iron produced in July included 290,300 tons of hematite, 253,400 tons of basic, 118,700 tons of foundry and 53,500 of forge quality. The following figures compare the production of pig-iron and steel in the first seven months of 1920 with the similar period in 1919. The total products of pig-iron in the first six months of 1919 was 3,954,000 tons against 4,145,000 tons for 1920. Of steel ingots and castings the output in the six months of 1919 was 4,264,000 tons and for 1920 4,877,000 tons.

LARGE DISCOVERIES OF IRON ORE AT KOURSK, RUSSIA.—What is likely to prove a very important discovery has been made by two Swedish scientists who have been following up the investigations made by the late Russian Professor Ernst Leyst of Moscow. Professor Leyst discovered magnetic disturbances of greater intensity than had ever before been observed and he studied these phenomena for a number of years. With much trouble the results of his labours were rescued and brought to Sweden, and the two Swedish scientists above referred to have arrived at the conclusion that the magnetic disturbances must be due to the existence of immense deposits of magnetic iron ore. It has been ascertained, as far as the research work goes at present, that there are two parallel deposits of iron ore at a distance of 60 kilometres apart, and each having a length of 108 kilometres. It has not yet been possible to arrive at anything like definite results as to the quantity or the quality of the ore present, but the Swedish experts are of opinion that the deposits will be found to be the largest in the world.

THE LATE SIR NORMAN LOCKYER, F.R.S.

Sir J. Norman Lockyer, who, we regret to record, died at Sidmouth, South Devon, on Monday, August 16, attained the same mature age of 84 years as the great astronomer of Meudon, near Paris, Pierre-Jules-César Janssen, with whom he shared the honour of the discovery that the solar chromosphere and the prominances in particular could, with the aid of the spectroscope, be studied any day when the atmospheric conditions were favourable, and not only during solar eclipses, as had been previously supposed. Curiously enough, papers dealing with this discovery were read by the two astronomers on the same day in 1868 before the Paris Académie. Both were awarded the special medal struck in commemoration of the event, and Lockyer, also elected a Fellow of the Royal Society in 1869, decided to devote his life to astronomy and to what we now call astrophysical research.

Janssen—Lockyer's senior by twelve years—had first seen the lines of a new element helium in the solar atmosphere, and his subsequent efforts to distinguish between solar and terrestrial lines in the spectrum finally, in 1892, brought him up to the Mont Blanc Observatory, whose foundation he had instigated. The search for helium on our globe was one of Lockyer's first solar-physical problems. Working, still in 1868, together with the chemist Edward Frankland, he had failed to find helium, which they rightly supposed to be a gas like hydrogen; but the Government had become interested, and Lockyer was appointed to the newly established Solar-Physics Observatory at South Kensington. He was Director of the Observatory from 1885 to 1913, and able to organise it for the study of problems of his own. When the observatory was transferred to Cambridge in 1913, after nearly forty years of existence, he took up similar work at the Hill Observatory, Salcombe Regis, near Sidmouth, in the foundation of which he was mainly instrumental. Operations at the Hill Observatory had to be practically suspended during the war, but there is every prospect of good work being done there in the future.

Another undertaking for which Lockyer is widely known, also dates back to the time of his first momentous success. In 1869 he started, and for many years edited, the weekly journal *Nature*, which now remains as indispensable as it was in its first year when Huxley was ready to write the opening lines.

Joseph Norman Lockyer was born at Rugby on May 17, 1836, and was educated in private schools and on the Continent; his D.Sc., LL.D., &c., were honorary degrees from Cambridge, Oxford and other Universities. By 1857 he was in the War Office. In 1861 he edited the Army Regulations; in 1870 he was appointed Secretary to the Royal Commission (Duke of Devonshire's) on Science; in 1875 he was transferred to the Science and Art Department. In connection with these duties he lectured and wrote quite a number of more or less popular astronomical books, in addition to some 200 papers, mostly presented to the Royal Society. As chief of eight British Government solar-eclipse expeditions during the years 1890 to 1905, he enjoyed exceptional facilities for direct observation. His "Meteoritic Hypothesis" of 1890, his classification of the stars according to rising and falling temperature, his views on enhanced lines and his "Dawn of Astronomy" of 1894—in which he advocated astronomical archæology, suggesting that temples and stone circles like Stonehenge seemed to have specially been constructed so as to facilitate the observation of solstices and equinoxes, and that the age of the structures could thereby be estimated—bore good fruit, though they also involved him in several controversies.

His presidential address to the British Association at Southport in 1903 on the "Influence of Brain-Power on History," was a vigorous protest against the neglect of brain power in this country, the Universities having, he urged, too much been the blind leaders of the blind, and he called upon the Government to do for brain power what they had done for sea power by duplicating the Navy Bill. The outcome of this address was the British Science Guild, of which he was President in 1912, and in which Lady Lockyer (his second wife, daughter of the late Mr. Samuel E. Browne, of Bridgwater and Clifton) is very actively interested. The youngest of his five sons, Dr. W. J. S. Lockyer, is the chief assistant at the Hill Observatory.

The funeral of Sir Norman is to take place to-morrow (Saturday), at 11 a.m., at Salcombe Regis.

The Royal Sanitary Institute.—The next Congress of the Royal Sanitary Institute will be held at Folkestone towards the end of June, 1921, by invitation of the Mayor and Corporation.

Dutch Shipbuilding.—According to *Moniteur de la Flotte*, the Dutch shipbuilding yards last year built only 183 ships. Among these were 92 steamers, 23 sailing ships fitted with auxiliary motors, 2 motor-driven cargo boats, 12 tugs, 112 fishing boats, 1 warship and 39 launches. Of these, 38 units were built for foreign buyers.

SPRING SCRAGGING MACHINE.

CONSTRUCTED BY MESSRS. SAMUEL DENISON AND SON, LTD., ENGINEERS, LEEDS.

(*For Description, see opposite Page.*)

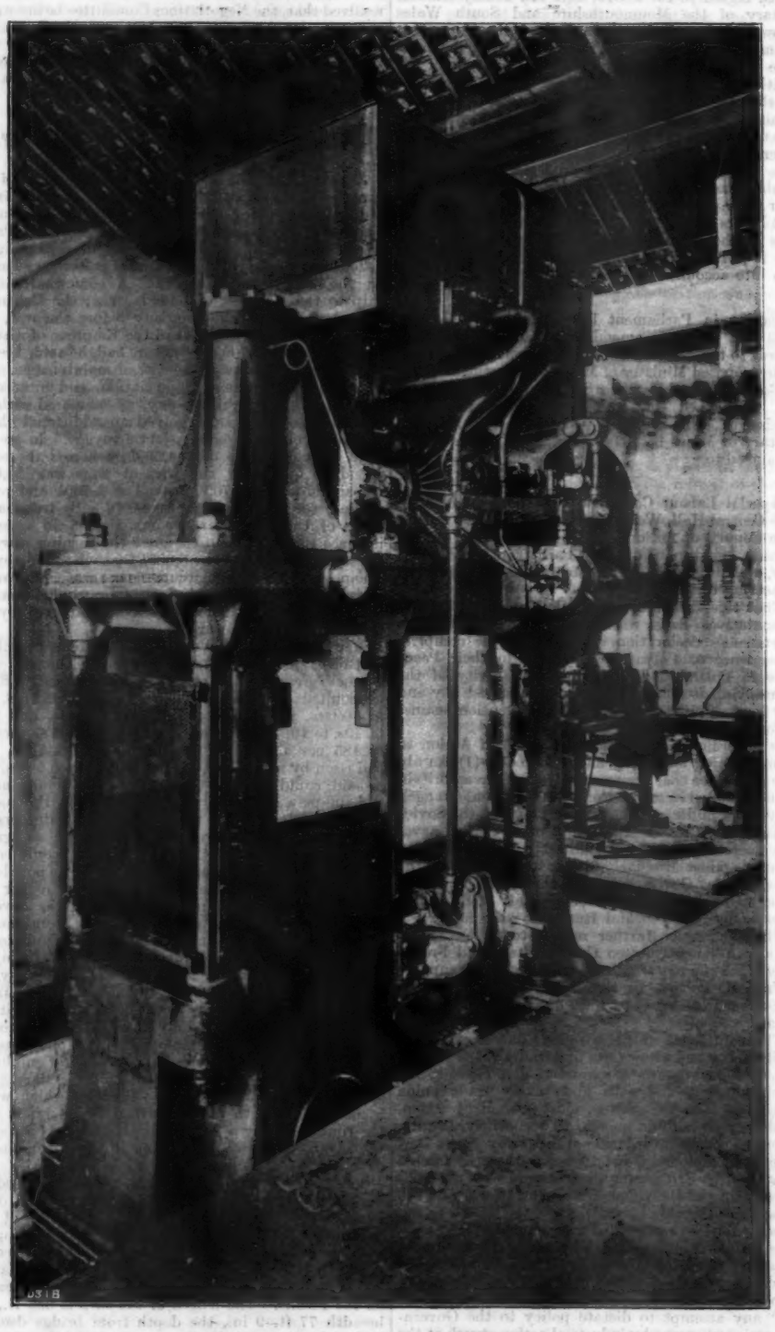


Fig. 1.

Queensland's Coal Production.—The annual report of the Queensland Department of Mines states that the total quantity of coal raised in the State last year was 931,631 tons, valued at 614,307*l.*, a decrease of 51,562 tons in production on 1918, but an increase of 42,002*l.* in value. There were increases both in quantities and values on the Darling Downs, at Maryborough, Rockhampton, and in the northern district, while Clermont recorded a lessened output but a rise in values. There were 48 collieries in operation in Queensland, of which 25 were in the Ipswich district.

A 5,000-kw. Rotary Converter.—When the Peiner Walzwerke, which are on three-phase supply, wanted more direct current for their rolling mill five years ago, they decided to put in one big rotary converter as floor-space was very limited, although they were warned against a 5,000-kw. unit. The scheme was, however, carried out by the Siemens-Schukert Company, and has answered so well that a second unit of the same size has recently been ordered. The converter is illustrated in *Stahl und Eisen* of June 24 last. The electric power supply for the works is generated three-phase at 50 periods and 10,000 volts in the Ilseder colliery, at a distance of 8 km. from the works at Peine, the generators being driven by internal-combustion engines using blast-furnace gas. For the rotaries the current is transformed to six-phase 384 volts in an oil transformer which weighs 10 tons. The rotary runs at 215 r.p.m. and weighs 46 tons, the heaviest single part to be lifted weighing 21 tons. The armature has 28 main poles; each slip ring is provided with 40 carbon brushes. In the full-load tests the converter efficiency was 94 per cent.

SPRING SCRAGGING MACHINES.

CONSTRUCTED BY MESSRS. SAMUEL DENISON AND SON, LTD., ENGINEERS, LEEDS.

Fig. 2.

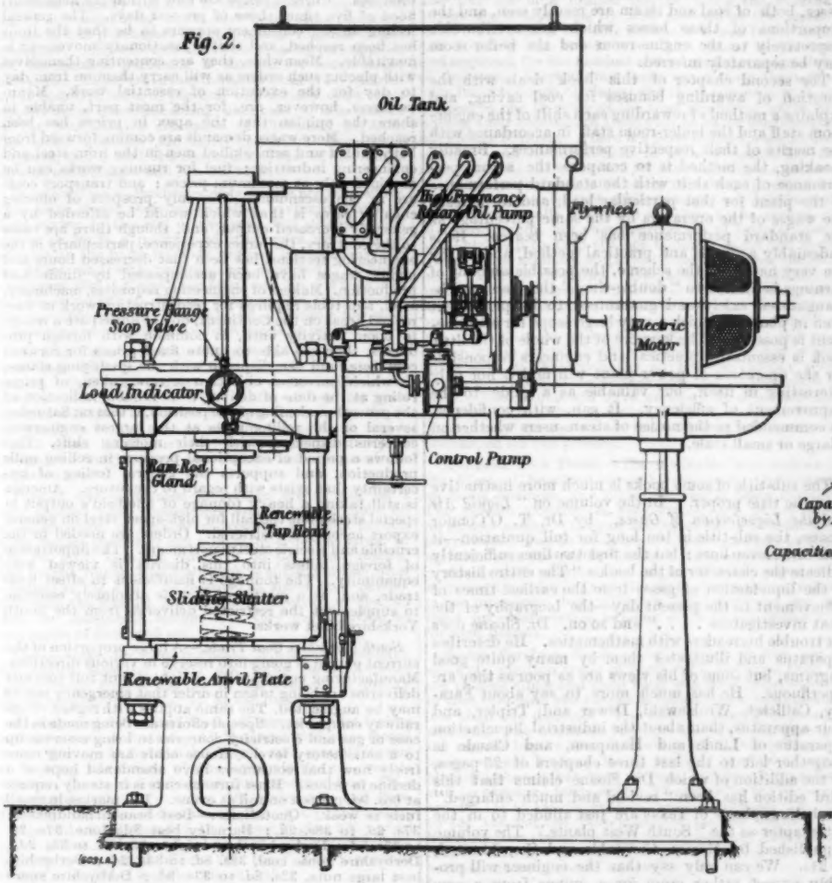
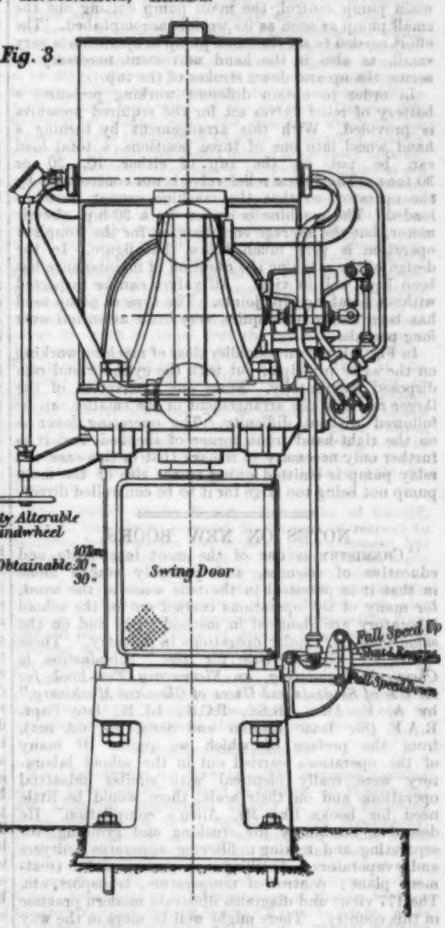


Fig. 3.



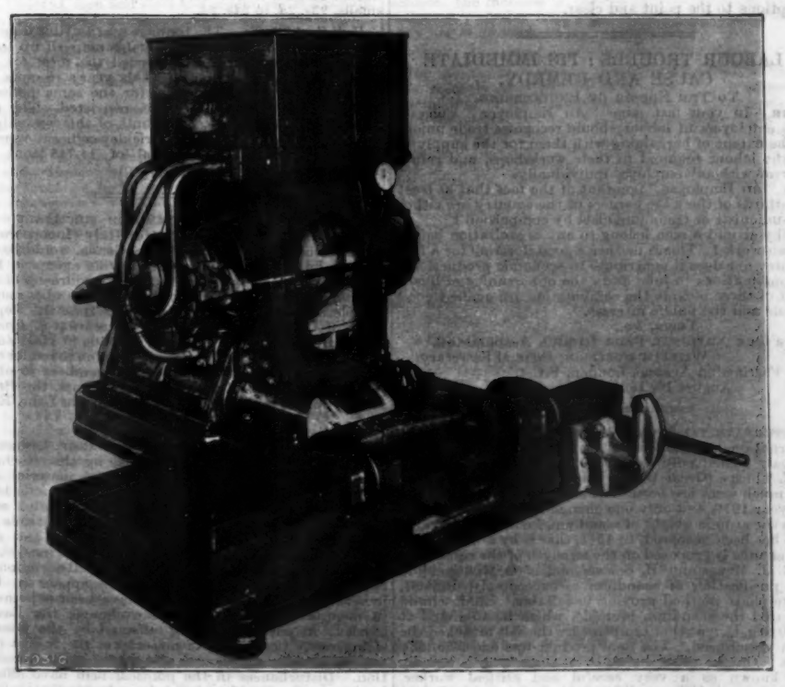


FIG. 4.

A NEW departure in the design and operation of spring scragging machines has recently been made by Messrs. Samuel Denison and Son, Limited, Hunslet Foundry, Leeds. The ordinary scragging test applied to springs consists of, in the case of laminated springs, flattening the camber, or in the case of springs of no camber, giving the spring a certain deflection, and in the case of helical or volute springs closing them hard down. The operation is repeated several times in order to represent extreme working conditions.

The system now adopted by Messrs. Denison for this work is one embodying a motor-driven variable rotary oil pump on the Hele-Shaw principle. The pump supplies oil to a cylinder of which the piston rod is fitted with a tup head. A machine on this principle recently supplied to Messrs. Cammell Laird and Co., Sheffield, is illustrated in Figs. 1, 2 and 3, on the present and opposite pages. The scragging gear is virtually a vertical press, with a horizontal table or anvil and a vertical inverted cylinder overhead. The cylinder ports are coupled direct to the rotary oil pump, the latter being mounted on a platform on which is also the driving motor. Above is a supply tank of oil of sufficient capacity to give continual service without overheating.

The energy put into the spring on the down stroke serves to return the tup to its normal position without the use of the pump. Owing to the piston rod on the under surface of the piston, the effective cylinder volumes on the two sides differ. In order to get rid of the surplus oil on the upper side of the piston on the up stroke therefore it is bye-passed back to the replenishing tank by means of a shuttle valve in the service pipe connecting the top of the cylinder and pump. This valve operates the bye-pass as soon as the pump is put in the neutral position. While the tup is moving up the underside of the piston is supplied with oil by suction, some of the oil from the top side of the piston being bye-passed to the underside for this purpose.

It is possible with this arrangement to obtain about 40 complete strokes of the tup per minute. For this a large pump unit is necessary. In order to assist in

rapidly controlling this a small relay pump is introduced into the system as shown in the illustrations. The latter pump is controlled by the operator by means of a lever, to be seen in Fig. 3, and hunting-gear to the main pump control, the main pump cutting out the small pump as soon as its work is accomplished. The effort needed to set the small pump in operation is very small, as also is the hand movement necessary to secure the up and down strokes of the tup.

In order to obtain different working pressures a battery of relief valves set for the required pressures is provided. With this arrangement by turning a hand wheel into one of three positions a total load can be put on the tup of either 10, 20 or 30 tons. The 30-ton relief valve is not controllable by the operator, so that the machine cannot be overloaded. The machine is driven by a 30-h.p. electric motor, but the average consumption for the complete operation is very much below that figure. In the design of the machine the question of maintenance has been kept well in view. All valves can be inspected without breaking pipe joints. The type of pump used has been shown to require very little attention over long periods.

In Fig. 4 is shown a smaller class of machine working on the same principle, but with the cylinder and ram disposed horizontally. From our description of the larger machine the arrangement of the smaller can be followed without difficulty. The operating lever is on the right-hand front corner of the bed, and it is further only necessary to remark that in this case the relay pump is omitted owing to the size of the main pump not being too large for it to be controlled direct.

NOTES ON NEW BOOKS.

"Chemistry is one of the most interesting and educative of sciences, and probably stands alone in that it is practical in the true sense of the word, for many of the operations carried out in the school laboratory are identical in method with, and on the same scale as, similar operations in industry." These words are characteristic for the "*Introduction to Chemical Engineering, an Elementary Text-Book for the Use of Students and Users of Chemical Machinery,*" by A. F. Allen, B.Sc., F.C.S., LL.B., late Capt. R.A.F. (Sir Isaac Pitman and Sons, 10*s.* 6*d.* net), from the preface of which we quote. If many of the operations carried out in the school laboratory were really identical with similar industrial operations and on their scale, there would be little need for books like Mr. Allen's compilation. He describes machinery for crushing and grinding, for separating and mixing; filtering apparatus; dryers and evaporators; distilling apparatus; water treatment plant; control of temperature, transport, etc. The 177 views and diagrams illustrate modern practice in this country. There might well be more in the way of general remarks and descriptions in the 270 pages. The reader may miss chapters on fuel and furnaces and on pumps; but he will find something on coke-ovens, kilns and roasting furnaces under distilling apparatus, and pumps under transport. The Kestner film evaporators are described in the section on multiple-effect vacuum pans. As regards permutit, we read that a solution of salt converts, by mass action, the permutit back to its original condition. This is all the explanation offered on this subject and literature references are nowhere given.

Many books have been written to expound the principles of efficient power plant operation, but the average engineer is already fairly conversant with the theoretical conditions which make for efficient working. In his own efforts after economy, he realises that he is usually handicapped, not only by the limitations of the plant which he has to operate, but still more by the fact that he possesses no criterion by which to judge the results he is getting, nor any information as to the degree of efficiency which it is practically possible for him to attain. The greatest incentive to improvement is an objective to be realised, and there is no stimulus to operating engineers so great as a constant comparison between the actual operating results and the possible performances of the plant at all loads. In "*The Coal Consumption of Power Plants and Bonuses for Coal Saving*" (London, *The Electrical Review* price 1*s.* net) the author, Mr. R. H. Parsons, has shown how, from the log-sheet records of any station, the standard performance of that station on every load may be deduced. Thus the operating engineer has before him a definite standard of efficiency with which he can compare his actual results, shift by shift, and can note immediately the improvement or otherwise brought about by any change in the operating conditions. The standards of efficiency, both for coal and steam consumption are linear equations, which may of course, be represented graphically by straight lines on a chart. These lines can be determined by anyone with no knowledge whatever of mathematics, and the comparison of any operating result with the standard is effected merely by plotting the result on the chart and noting whether and how much it lies above or below the line. From the standard equations, many very useful facts concerning the station may be obtained. The no-load consumption, or standby losses, both of coal and steam are readily seen, and the proportions of these losses which are attributable respectively to the engine-room and the boiler-room may be separately inferred.

The second chapter of this book deals with the question of awarding bonuses for coal saving, and explains a method of rewarding each shift of the engine-room staff and the boiler-room staff in accordance with the merits of their respective performances. Broadly speaking, the method is to compare the actual performance of each shift with the standard performance of the plant for that particular load, and to increase the wages of the operators by the same percentage as the standard performance has been beaten. It is undeniably a simple and practical method, and as, by the very nature of the scheme, the possible amount of earnings is limited to "double-time" the plan may be inaugurated safely and guaranteed to be permanent even in plants in which a very large scope for improvement is possible. The keynote of the whole of the little book is essentially practical and engineers responsible for the operation of power plant will find it not only interesting in itself, but valuable as a guide to the improvement of efficiency. It can, with confidence, be commended to the notice of steam-users whether on a large or small scale.

The sub-title of some books is much more instructive than the title proper. In the volume on "*Liquid Air and the Liquefaction of Gases,*" by Dr. T. O'Connor Sloane, the sub-title is too long for full quotation—it runs into eleven lines; but the first two lines sufficiently indicate the character of the book: "The entire history of the liquefaction of gases from the earliest times of achievement to the present day—the biography of the great investigators . . . ," and so on. Dr. Sloane does not trouble his readers with mathematics. He describes apparatus and illustrates them by many quite good diagrams, but some of his views are as poor as they are superfluous. He has much more to say about Faraday, Cailletet, Wroblewski, Dewar and Tripler, and their apparatus, than about the industrial liquefaction apparatus of Linde and Hampson, and Claude is altogether left to the last three chapters of 25 pages, by the addition of which Dr. Sloane claims that this third edition has been "revised and much enlarged." The helium plants of Texas are just alluded to in the last chapter as the "South West plants." The volume is published by Messrs. Constable and Co., Limited, at 21*s.* We can only say that the engineer will probably expect rather more for a guinea from a new edition of a work on liquid air, though the general reader will find the book quite interesting and the descriptions to the point and clear.

LABOUR TROUBLE: ITS IMMEDIATE CAUSE AND REMEDY.

To The Editor of Engineering.

Sir,—In your last issue "An Employer" suggests that employers of labour should recognise trade unions to the extent of bargaining with them for the supply of all the labour required in their workshops, and refuse to treat with any employee individually.

Is "An Employer" ignorant of the fact that at least two-thirds of the wage earners of the country are either non-unionists or trade unionists by compulsion?

Why should a man belong to any organisation before he can work? This is neither a good doctrine for a free country nor does it contribute to economic production?

Combinations to take away the opportunity of livelihood of those outside the combination are against good morals and the public interest.

Yours, &c.,

For The National Free Labour Association,
William Collison, General Secretary.

5, Farringdon Avenue, London, E.C.4.
August 16, 1920.

International Atomic Weights.—The Report of the International Committee on Atomic Weights for 1920–21 is again signed only by F. W. Clarke (United States), T. E. Thorpe (Great Britain), and G. Urbainy (France). Not much work has been done on atomic weights during the year 1919, and only one change is proposed, viz., to raise the atomic weight of scandium, for which the value 44·1 has been accepted, to 45·1, that is by a whole unit. The change is proposed on the strength of the researches of R. J. Meyer and B. Schweigand of O. Hönigschmid The purification of scandium is exceedingly difficult, the sulphate method proving unsuitable. Hönigschmid prepared the scandium bromide, which he sublimed at 1,000 deg. C.; at that temperature the salt attacked the silica vessel used. The final product was exceptionally pure. On the other hand, P. A. Guge, who is equally well known as a very careful and critical worker, has suggested slight modifications of the atomic weight of bromine and silver, data which are almost fundamental for atomic weight determinations.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—A cautious spirit prevails among both home and overseas buyers of steel and engineering products. Current prices are now within the neighbourhood of five times those of pre-war days. The general feeling among consumers appears to be that the limit has been reached, and that a reactionary movement is inevitable. Meanwhile, they are contenting themselves with placing such orders as will carry them on from day to day for the execution of essential work. Manufacturers, however, are, for the most part, unable to share the opinion that the apex in prices has been reached. More wages demands are coming forward from both skilled and semi-skilled men in the iron, steel and engineering industries; fuel for running works can be obtained only at maximum prices; and transport costs are in the ascendant. The only prospect of offering cheaper rates is that which would be afforded by a generally increased output, and, though there are cases to the contrary, the larger experience, particularly in the engineering sections, has been that decreased hours and higher wages have been accompanied by diminished production. Makers of engineering requisites, machinery, steel, and tools required for reconstruction work in war-racked areas on the Continent, do not anticipate a return to boom activity until, in common with foreign producers, they are able to quote fixed prices for forward contracts, and can dispense with the qualifying clause, to which universal objection is now taken, of prices ruling at the date of delivery. A reliable indication of the general weakening of the position, is that on Saturday several of the rolling mills at the largest engineering concerns dispensed with their morning shift. This follows a period of exceptional pressure in rolling mills production, and supports the general feeling of uncertainty that exists with regard to the future. America is still taking a heavy tonnage of Sheffield's output of special steels, but the call for high-speed steel on general export account is restricted. Orders are needed in the crucible and electric steel departments. The importation of foreign billets into this district is viewed with equanimity. The tonnage is insufficient to affect local trade, and, as a matter of fact, is absolutely essential to supplement the restricted deliveries from the South Yorkshire billet works.

South Yorkshire Coal Trade.—A large proportion of the current output is going into reserve in various directions. Manufacturing consumption is lighter, but full contract deliveries are being taken in order that emergency stocks may be augmented. The same applies with regard to the railway companies. Special efforts are being made in the case of gas and electricity concerns to bring reserves up to a satisfactory level. House coals are moving more freely now that consumers have abandoned hope of a decline in prices. Blast furnace coke is in steady request at 65*s.* 9*d.* per ton on rail at ovens. The market in small fuels is weak. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

Hull Coal Traffic.—The tonnage sent to Hull from this district last month, 171,326 tons, came well up to the average for the year, and exceeded the total for July of last year by 41,000 tons. This year's receipts now practically approximate those for the same period of 1919. Exports were, of course, restricted. The total reached only 4,701 tons. The bulk of this was shipped to France. Grimethorpe and Frickley collieries were the chief contributors. Their total of 14,748 tons was practically double that of a year ago.

British Chamber of Commerce for Italy.—The British Chamber of Commerce for Italy (Incorporated), Head Office at 7, Via Carlo Felice, Genoa, would be glad if firms in the United Kingdom having agents in Italy would give the chamber the names and addresses of such agents, in order that the records of the Chamber may be complete and accurate. At the same time the Department of Overseas Trade calls the attention of firms in the United Kingdom interested in trade in Italy to the services which the Chamber is in a position to render them and recommends firms not already members to obtain particulars from its London correspondents, the British Italian Commercial Association, 12, Nicholas Lane, E.C.4.

The London Iron and Steel Exchange, Limited.—The two last weekly reports issued by this Exchange state that offers of Belgian structural material have been received in this country at several pounds below British makers' prices. At the moment, Belgium seems to be the only competitor. British export trade still remains listless, and it is becoming more and more evident that the future course of the report market will depend upon financial developments. Restrictions in the accommodation given by banks appear to have increased of late and difficulties have been experienced in negotiating foreign bills of exchange, the Eastern markets in particular being affected by the financial stringency. Congestion of material at the Indian ports and up country warehouses also comes in for consideration. Disturbances in the political field have affected business unfavourably; but it is undoubtedly the financial position that is having the greatest adverse effect upon trade at the present moment.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Holiday-making is general as is usual during the local race week on Tees-side. Cleveland foundry pig-iron is considerably less scarce, due to the consuming works here being shut down for the week, but purchasers are still unable to place orders for export. All home consumers are pressing for supplies, and Scotland in particular is anxious for much larger deliveries. There are in fact inquiries from every quarter of the country, users of pig-iron who usually draw their supplies from elsewhere being attracted to this market by the comparative cheapness of Cleveland pig-iron. The lower qualities are fairly plentiful. For home purposes, No. 3 and the commoner kinds of Cleveland pig-iron are 217*s.* 6*d.* and No. 1 is 230*s.*

Hematite Iron.—Producers of hematite are not selling. They have closed their books, after having disposed of their output to the end of the year, but second hands appear to be in a position to offer more iron, and, in addition to the home business passing, transactions with the Allies, and with neutrals, are reported. To home customers, Nos. 1, 2 and 3 are 260*s.*, and No. 1 is 262*s.* 6*d.*; and for shipment to France, Belgium and Italy, mixed Nos. are 265*s.* and No. 1 is 267*s.* 6*d.*; whilst a few sales of hematite to neutrals have been made at up to 300*s.*

The New Railway Rates.—The new railway rates which come into force next month are much discussed by traders. It is fully understood that so far as Cleveland foundry iron is concerned the extra charge for conveyance will have to be borne by purchasers, but this is not likely to be the case as regards hematite, in which branch much relief must be felt through the slump in foreign ore freights, and the cheaper rates named for imported ore.

Foreign Ore.—Business in foreign ore is still on a very limited scale, consumers continuing to hold off in anticipation of further movement in their favour. They declare that they can now place orders at equal to 47*s.* 6*d.* c.i.f. Tees for rubio, of 50 per cent. quality. The freight Bilbao-Middlesbrough is slightly firmer after a fixture at 17*s.* 4½*d.* So recently as March last chartering from the Spanish ore port were recorded at 39*s.*, so that the collapse in freight is a very great saving to consumers of imported ore.

Coke.—Coke, for local purposes, is not over plentiful, but really essential needs are being met. Average blast-furnace kind is 62*s.* 9*d.* at the ovens, and quality low in phosphorus is 65*s.* 3*d.* at the ovens.

Manufactured Iron and Steel.—There is a quiet feeling in finished iron and steel. All the local works are closed down this week for the holidays, and manufacturers are taking advantage of the opportunity to execute repairs. Common iron bars are 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; rivets, 38*l.*; channels and flats, 23*l.* 5*s.*; rounds and squares, 25*l.* 10*s.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; steel angles, 23*l.*; steel boiler plates, 30*l.*; steel joists, 23*l.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy sections of steel rails, 25*l.*; and fish plates, 30*l.*

PERSONAL.—At the recent annual meeting of William Firth, Limited, iron and steel and machinery merchants, Leeds, Mr. Dennis Armitage, who has been in the employment of the company for many years, was appointed a director, together with Mr. Bernard A. Beach, who, previous to the war was engaged with the South Kirkby, Featherstone and Hemsworth Collieries, Limited.

THE BRITISH ENGINEERING STANDARDS ASSOCIATION.—This Association has recently issued a Report, No. 122, 1920, dealing with British standards for milling cutters and reamers, and giving the results achieved in the standardisation of the nomenclature and definitions of these tools. A large number of tables of dimensions and tolerances are included and an index is added to facilitate reference. The work was undertaken in response to a direct request from the small tool and machine tool makers of the country. A fully representative conference was convened, as is the usual custom of the Association. Panels were appointed to carry out the various sections of the work, and these met in different parts of the country in the various centres of the tool industry, thus saving time to the members and bringing them into close touch with actual workshop practice. The panels included manufacturers of the actual tools, makers of the machines in which they were used, and representatives of the users. The tools considered were divided into four classes: non-relieved cutters, end mills, form relieved cutters and reamers. The Report opens with definitions of the various classes of milling cutters and reamers, then follows a valuable series of definitions of the various types of each class, each type being accompanied by a clear explanatory diagram. Part 2 contains 58 tables giving the standard dimensions and tolerances of the various tools, including tables of Brown and Sharpe and Morse tapers. Standard dimensions of arbors and keys and keyways are also given. A Report covering so wide a field of industry, whilst it should prove of great utility, is sure to be susceptible of amendment and it is hoped that experience in its use will indicate the directions in which any revision may be called for, and, in order that any advance in manufacturing methods may be given effect to, an opportunity is afforded at least once a year for the revision of all specifications issued by the Association. The price of the Report is 1*s.* 3*d.* post free, and copies can be obtained on application to the Secretary, 28, Victoria Street, S.W.1.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The demand for all classes of steel material is still large, but it is all, or nearly all, against contracts booked some time ago. Inquiries for new lots are of a limited nature, while the overseas buyers are conspicuous by their absence at the present time. The reason for this reticence is not far to seek, and is solely due to the very high prices demanded, and required, for the finished article, and the uncertainty of delivery. Shipbuilding firms are getting through a very large tonnage of plates, and those concerns with an interest in one or other of the steel producing works are finding their connection therewith to be of considerable advantage to them. There is a good outlet for structural sections, and accumulations in makers' hands are far from general. The demand for black sheets is as strong as it has ever been, and consumers keep pressing for supplies against contract, while new business is infinitesimal. Occasionally there are odd lots to be picked up in second hands, but these parcels are of little account, and only help to keep the pot boiling. With the home trade still so steadily employed, there is almost nothing being exported meantime. Galvanised sheets are strong and somewhat scarce. The matter of the current prices is always cropping up, and many buyers are still of opinion that these must weaken soon. How any shading can take place at present is difficult to see, and one factor which cannot be overlooked—apart from everything else—is that with the advance in railway rates at the beginning of September fuel will be increased in price. That alone will have an effect on steel material and instead of a fall in prices a rise is more probable. Meantime all quotations are firm and are likely to remain unchanged for the present.

Malleable Iron Trade.—The malleable iron makers in the West of Scotland are all very busy, particularly on home business, and little material is being shipped. The present position is very strong and prices show no sign of easing. Output continues fairly satisfactory, but it would need to be on a more generous scale to keep up with ever increasing demands from consumers who could do with considerably larger deliveries than they at present receive. Inquiries from overseas are rather more numerous, but although little business can be fixed up consideration is being given to the booking of forward parcels.

Scotch Pig-Iron Trade.—The scarcity of iron ore is what the pig-iron trade of Scotland is suffering from at the present time, and until there is a good improvement in that direction the output is bound to be considerably less than the demand. The latter is very pronounced, and when the available tonnage is distributed amongst the regular buyers there is nothing left over for the new or occasional buyer. No. 1 foundry iron is no more plentiful than it has been of late, but No. 3 grade can still be obtained fairly easily. The price for the former is around 14*l.* to 14*l.* 5*s.* per ton, and for the latter 13*l.* 10*s.* to 13*l.* 15*s.* per ton, both loaded at makers works. For hematite iron there is a very pressing demand from steelmakers who are getting through as much as producers are able to send them, and next to nothing is available for export. The high price of 14*l.* 5*s.* per ton delivered does not have any effect on the demand. Quotations all round are very firm and, as already stated in this column, the increase in railway rates a fortnight hence will most probably send pig-iron prices still higher than they are at present.

HYDROELECTRIC POWER FOR AUSTRIAN RAILWAYS.—The recently formed Water Power and Electricity Commission of Austria has decided at a conference to limit the electrification of the State railways for the present to some sections of the western lines of what remains of Austria. The Commission comprises members of the Government, representatives of the cities, the industries, financial and technical institutions, of agriculture and forest culture, of labour, and also of those interested in the care of visitors to the country. The cost estimate of the planned electrification rose considerably while the preliminary drafts were being examined, to 5,100,000,000 kronen. It is hoped that the adoption of hydroelectric power will save the State 434,850 tons of coal annually, out of a total of 3,500,000 tons available for the railways of the country.

A COAL TESTING STATION.—A coal-testing station is to be opened shortly at Kirkby-in-Ashfield, near Nottingham, by the Midland Coal Products, Limited, 1, Charing Cross, S.W. 1. This company has been formed with the object of testing coals and advising clients on the best methods of making use of them. It is pointed out that expert advice may easily enable products of any mine to be utilised much more advantageously than is done when, without bringing scientific knowledge to bear, coal is sold to the readiest bidder. Also in cases it may be possible to find uses for material hitherto treated as waste. Clients will be able to have samples tested on a reasonably large and practical scale. The plant is equipped with five retorts on different systems, with a gas producer plant, a briquetting plant capable of an output of 30 tons of briquettes in 10 hours, a condensing plant, steam plant and a laboratory. The latter is under the supervision of Dr. F. Mollwo Perkin. The plant is arranged for thorough analysis at all stages, and the equipment, in the form of measuring instruments, pyrometers, &c., is complete. The company will be in a position to undertake tests on classes of coal ranging from oil shales and lignites to bituminous coals. Bunkers each of 50 tons capacity are provided for sample fuels.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Though the strike of railway fitters has ended, the effects of the stoppage and a consequent shortage of locomotives continues to affect the movement of coals and the return of empty wagons to the pits.

In fact it is anticipated that the conditions prevailing before the strike will not be restored for at least another fortnight, meanwhile inland railway supplies continue to be diverted to export, and it is not expected that delivery of the usual quantities to the railways will be resumed until next week at the earliest. Despite this diversion of inland coal, the quantity available for export remains inadequate to meet the demand, mainly because of the fact that many miners are holiday making, with a consequent shortage in outputs. The docks are congested with vessels, and there are also a considerable number of steamers in the roads waiting for cargoes and bunkers. Some of these boats have been waiting for over a fortnight and the prospects of any improvement in the position are not considered bright. Unemployment at the docks as a result of diminished trade, chiefly due to restricted coal exports, is also causing much uneasiness, for trouble is threatened with the tippers because of the dismissal of 80 men. These 80 men have refused to take their discharge and are presenting themselves for work as usual, but the crisis is expected at the week-end, when these men apply for their wages. The position is aggravated by the fact that at the moment the Coal Mines Department is refusing to grant releases of large coal for all destinations except British coaling stations, and in consequence of this a number of boats with half their cargo are held up waiting for the release of coals to complete. Prices are more or less nominal on the basis of 115*s.* to 120*s.* for large, 92*s.* 6*d.* to 97*s.* 6*d.* steam smalls and 105*s.* to 110*s.* for throughs.

The Pitwood Strike Ended.—The strike of Cardiff, Penarth, and Barry pitwood dischargers in respect to payment for overtime has ended. An agreement has been signed granting the men 3*s.* 6*d.* for a quarter night and 1*l.* for a full night's work per man in addition to the ordinary tariff. The provisional tariff granting the men an increase representing about 20 per cent. also becomes operative with retrospective application from May 10 last. The strike of general cargo workers at Swansea is also ended, the claim of the men for 21*s.* per day, against the Shaw minimum of 16*s.* per day, in the case of the loading of the steamer Canadian Voyageur, over which the trouble arose, having been referred to a committee of the employers and men, who are also to consider future grievances that may crop up.

THE INSTITUTE OF METALS.—The autumn meeting of this Institute will be held in Barrow on Wednesday and Thursday, September 15 and 16. The following is an abstract of the programme:—On Wednesday, at 10 a.m., general meeting of members in the Town Hall, when a selection of Papers (including Nos. 11, 5, 3 and 7) will be presented and discussed. At 12.45 p.m. the meeting will be adjourned to the following day; 1 p.m., luncheon, by kind invitation of Messrs. Vickers, Limited, at their Barrow Works; 2 p.m. to 5 p.m., visits to works. On Thursday at 10 a.m., general meeting of members in the Town Hall. A selection of Papers (including Nos. 10, 2, 9 and 6, as well as any others for which time remains) will be presented and discussed. At 12 noon the general meeting will be concluded. At 12.45 p.m., luncheon at Furness Abbey Hotel, by kind invitation of the directors of the Barrow Hematite Steel Company, Limited. The following is a list of the Papers that are expected to be submitted:—(1) W. E. Alkins, M.Sc. (Manchester), on "The Immiscibility of Metals from the Point of View of the Phase Rule"; (2) Engineer Lieut.-Commander G. B. Allen, R.N. (London), on "Service Experience with Condensers"; (3) T. G. Bamford, M.Sc. (Birmingham), and W. E. Ballard (Birmingham), on "The Influence of Gases on High-Grade Brass"; (4) Kathleen E. Bingham, B.Sc. (Teddington), on "The Allotropy of Zinc"; (5) Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M., F.R.S. (London), and Constance F. Elam (New Barnet), on "Crystal Growth and Recrystallization in Metals"; (6) J. H. S. Dickenson (Sheffield), "Note on a Failure of Manganese Bronze"; (7) D. Hanson, M.Sc. (Teddington), and Marie L. V. Gayler, B.Sc. (Teddington), on "The Constitution of the Alloys of Aluminium and Magnesium"; (8) O. F. Hudson, D.Sc. (London), and J. H. Darley (London), on "The Constitution and Structure of Certain Tin-Antimony-Copper Alloys"; (9) F. Johnson, M.Sc. (Birmingham), on "Some Features in the Behaviour of Beta Brass when Cold-Rolled"; (10) R. T. Rolfe, F.I.C. (Bedford), on "The Effect of Increasing Proportions of Antimony and of Arsenic respectively upon the Properties of Admiralty Gun-Metal"; (11) H. B. Weeks, F.I.C., "Notes on Brass Foundry Practice at Messrs. Vickers, Limited, Barrow-in-Furness." A special Council meeting will be held in London on Wednesday, September 1, for the purpose of considering applications for membership. All applications that are found to be in order will be included in the ballot list to be issued to members on September 3. All applicants for membership whose forms are in the Secretary's hands before noon on September 1 will be entitled to take part in all the proceedings at the Barrow meeting. Members are asked by the Council to be good enough to convey this information to any of their friends who may be eligible for membership of the Institute, or to send the addresses of such friends to the Secretary. The new list of members is available on request.

2,000-TON ELECTRIC SLIPWAY MACHINERY; AYRSHIRE DOCKYARD CO., LTD.

CONSTRUCTED BY MESSRS. DAY AND SUMMERS, LIMITED, ENGINEERS, SOUTHAMPTON.

(*For Description, see Page 255.*)

Fig. 1.

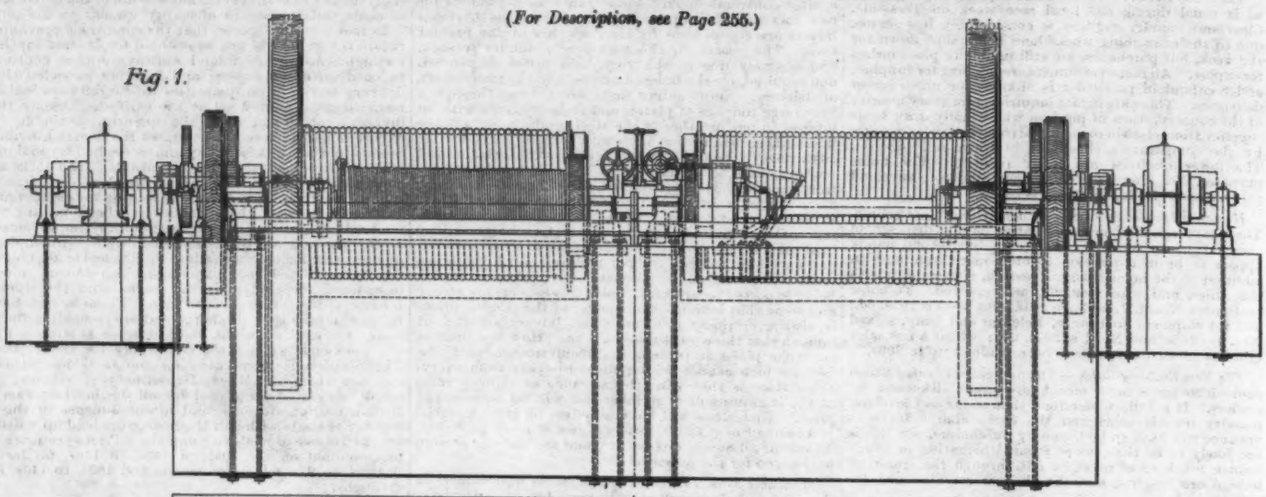
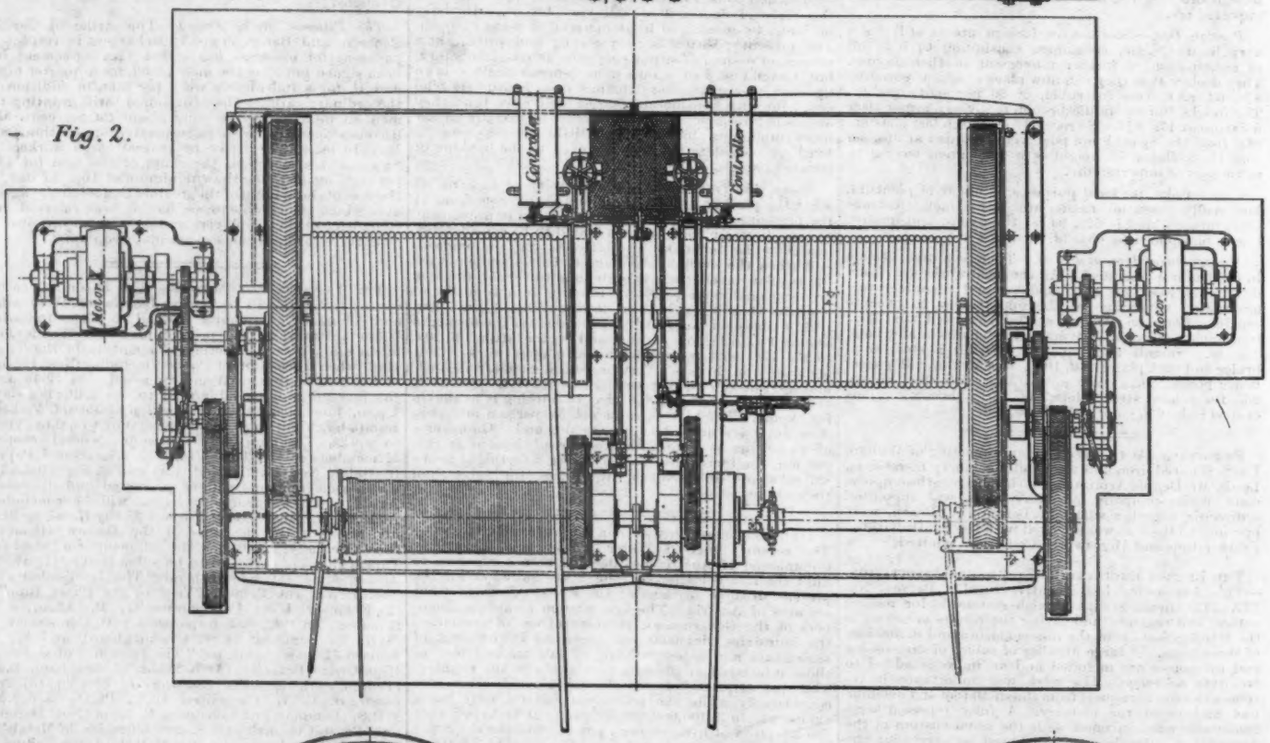


Fig. 2.



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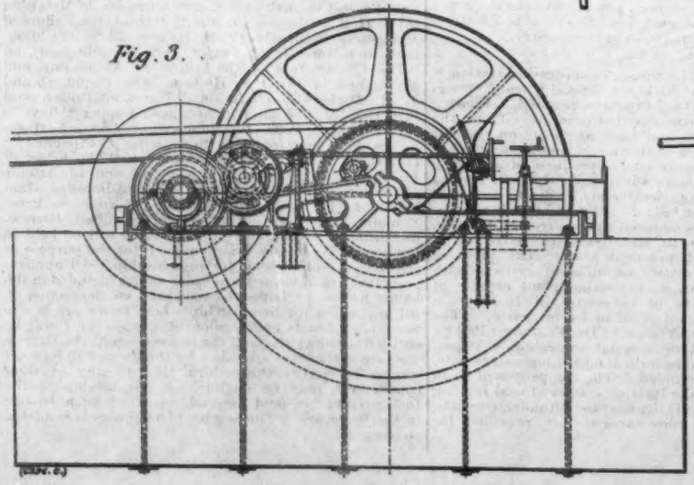

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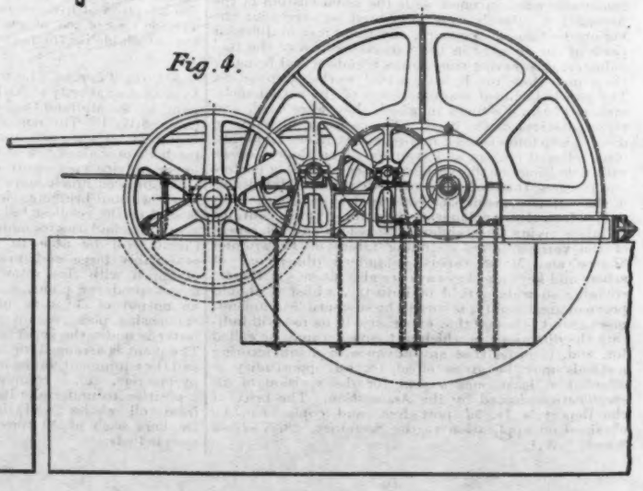
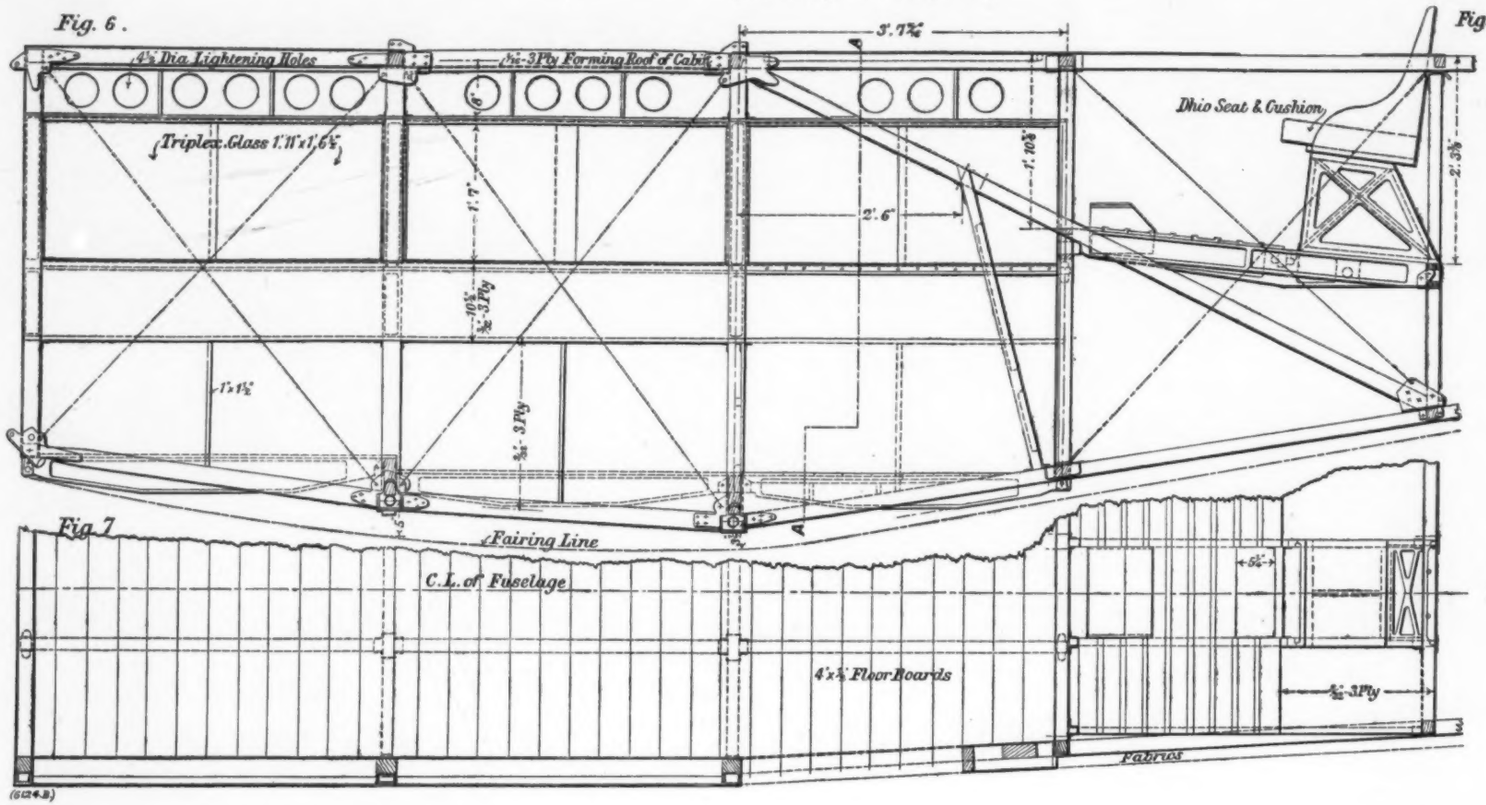
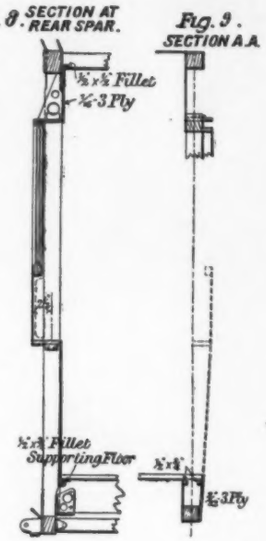


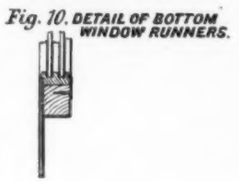
THE AIRCO 18 AEROPLANE: CONSTRUCTIONAL DETAILS.

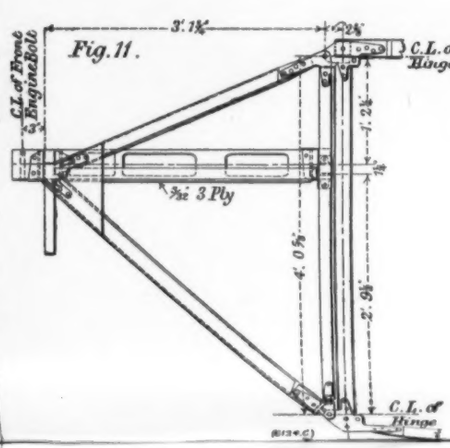
CONSTRUCTED BY THE AIRCRAFT MANUFACTURING COMPANY, LIMITED, HENDON, LONDON.

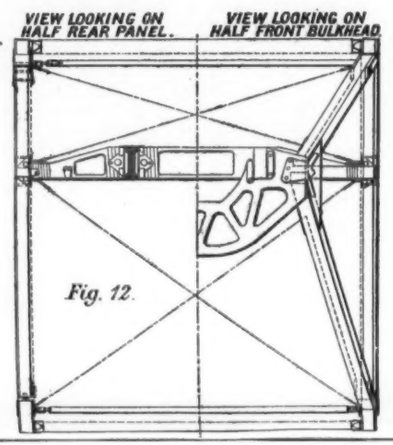
(For Description, see Page 238.)

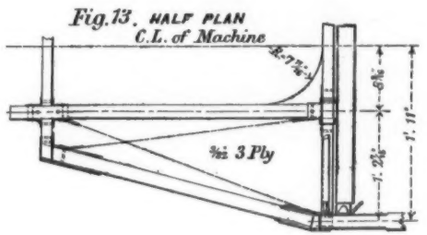


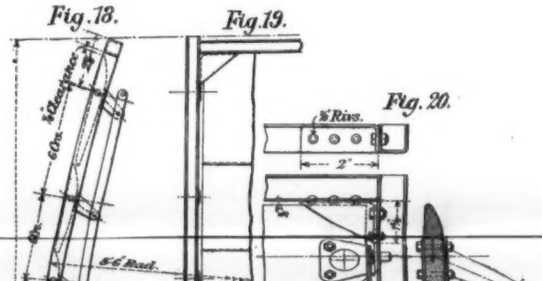


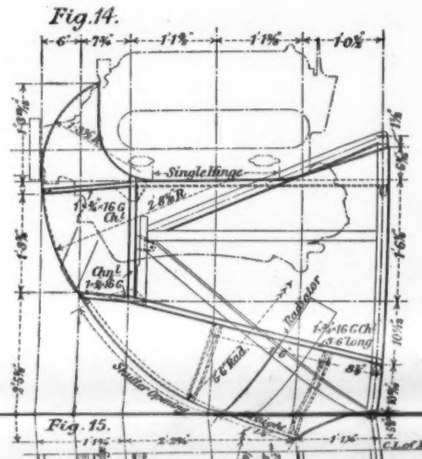


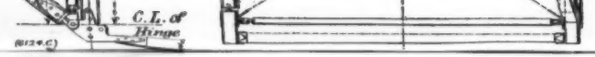


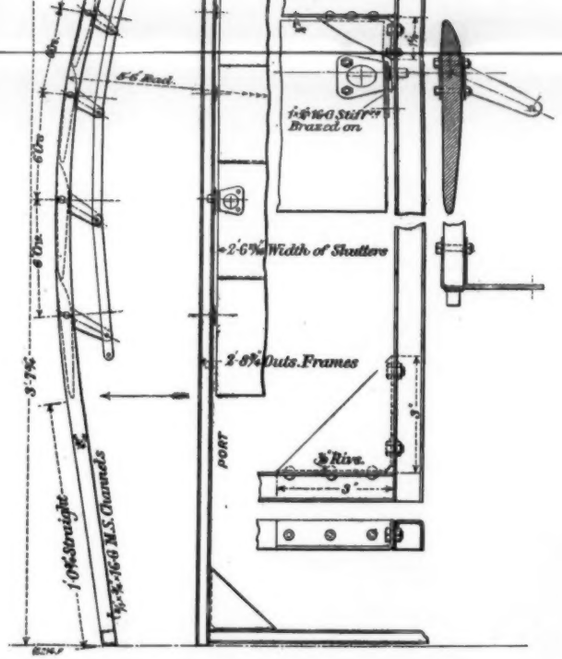









C.L. of Hinge


4'6" Rad.
1-3"×16 G Stiffrs Brazed on
2'-6⅞" Width of Shutters
2'-8⅞" Outs. Frames
5 Rivs.
3"
PORT
1'-0" Straight
3'-7½"
6'-0"
8'-0"
⅜"×3"×16 G M.S. Channels

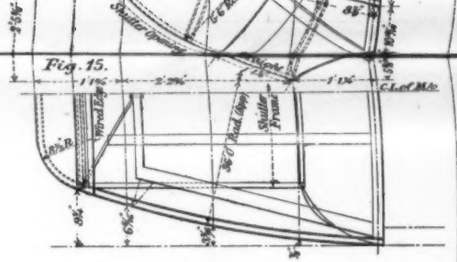


Fig. 15.
Wired Edge
Shutter Frame
C.L. of Mtr.

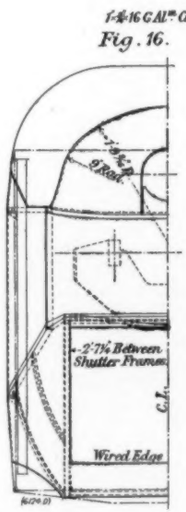
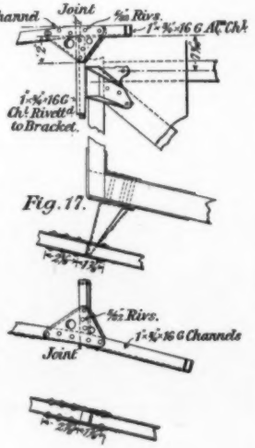


Fig. 16.
2'-7⅛" Between Shutter Frames
Wired Edge
C.L.


1-¾×16 G Al.m Channel
Joint
⅝" Rivs.
1-¾×16 G Al.m Ch.l
1-¾×16 G Ch.l Rivetted to Bracket.
Fig. 17.
⅝" Rivs.
1-¾×16 G Channels
Joint

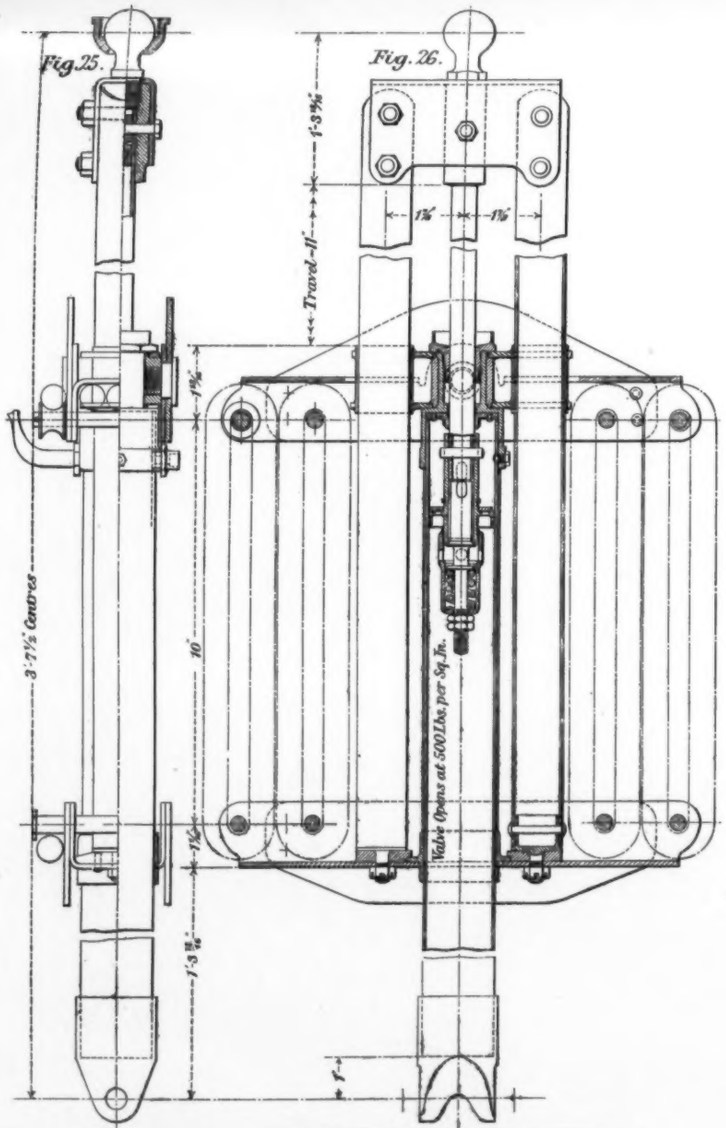


Fig. 25.
Fig. 26.
3'-7½" Centres
Travel-11"
1'-3⅝"
1⅝"
1⅝"
10"
1⅝"
1⅝"
1'-3⅝"
Valve Opens at 500 lbs. per Sq. In.
1'-

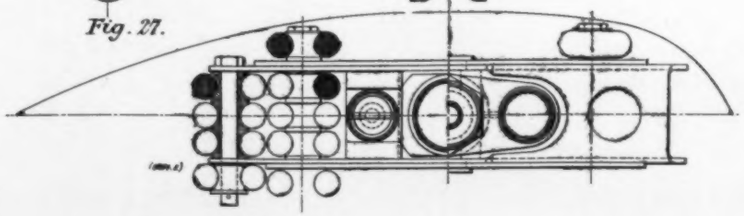


Fig. 27.

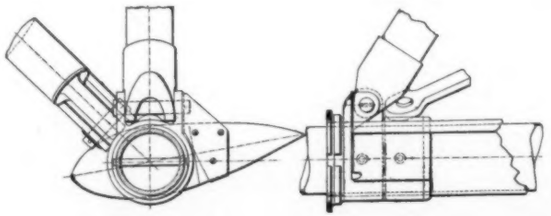
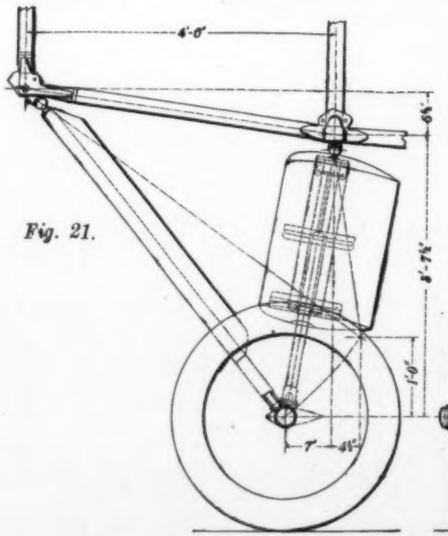


Fig. 23.
Fig. 24.


4'-0"
6½"
3'-7½"
1'-0"
7"
4½"
Fig. 21.

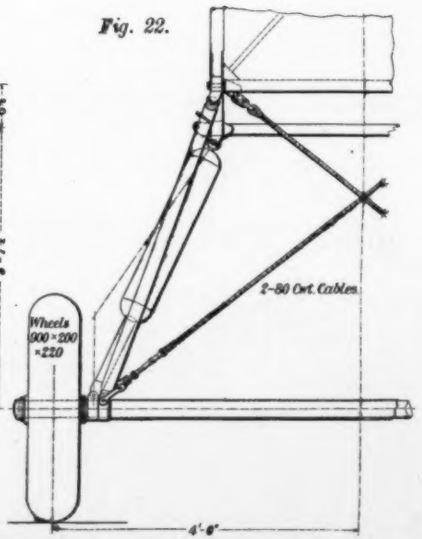


Fig. 22.
2-80 Cwt. Cables
Wheels 900×200 ×220
4'-8"

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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With a Two-Page Plate of the AIRCO 18 AEROPLANE: CONSTRUCTION DETAILS.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, AUGUST 20, 1920.

THE NEW UNEMPLOYMENT INSURANCE SCHEME.

AMONGST several important Bills passed by Parliament before rising for the autumn recess last Monday great interest will be taken in the Unemployment Insurance Bill, which has obtained the Royal Assent and will come into operation on November 8, 1920. As a result the number of persons in the United Kingdom insured against unemployment will be raised from about 4,000,000 to about 12,300,000, and the benefits will be increased to 15*s.* a week for men, 12*s.* for women, 7*s.* 6*d.* for boys under eighteen, and 6*s.* for girls. The contributions will be raised to 4*d.* both for men and for their employers, and 3*d.* for women and 3½*d.* for their employers. Boys and their employers will each pay 2*d.* a week, and girls will pay 1½*d.* and their employers 2*d.* The State's contributions are to be as follows: for every contribution paid in respect of a man 2*d.*, a woman 1⅔*d.*, a boy 1½*d.* and a girl 1*d.* It is estimated that of the 14,000,000*l.* of unemployment benefit which will be paid under the Act the employers will contribute rather over 6,000,000*l.*, the workpeople rather under 6,000,000*l.* and the State about 4,000,000*l.*

It is impossible in a short summary to state the effect of the Act in all its details, but the following notes may give a general idea of its provisions. The Act of 1911, which, so far as it relates to unemployment insurance, is repealed as from the commencement of the new Act, applied only to certain specified classes of workers. The new Act is made applicable in general terms, subject to specified exceptions, to employed persons in the United Kingdom and to seamen on British ships registered, or owned or managed by persons, in the United Kingdom. It applies to apprentices except those who get no wages. The earlier statutes did not apply to apprentices indentured under a strict instrument of apprenticeship, presumably because the master had no power to dismiss or suspend the apprentice or otherwise throw him out of his employment during the period of the indenture. This distinction, although logical, led to confusion and has been abolished. The Act does not apply to persons employed in agriculture, domestic service or the forces of the Crown, or to employment otherwise than by way of manual labour at a remuneration of more than 250*l.* a year; and in certain cases persons in the employment of local or other public authorities, police forces, or railway companies, or in the teaching profession, &c., are or may be excepted from its operation. The employer is to pay, in the first instance, both his workers' contributions and his own, but he may deduct the workers' contributions from their wages. The regulations to be made by the Minister of Labour will provide for payment being made by means of stamps on cards or books, as at present.

Before an insured person can obtain benefit not less than twelve contributions must have been paid in respect of him, except during the first year from the commencement of the Act, when four contributions suffice for an aggregate of eight weeks' benefit, and he must be capable of work but unable to obtain suitable employment. He is not bound to accept "blackleg" employment or employment at a rate lower than his district rate. (Sections 7 and 43.) There is a special provision, in Section 41, for having soldiers and seamen who are discharged after July, 31, 1920, credited with the contributions necessary to enable them to qualify for unemployment benefit.

Benefit is to be payable in respect of each week after the first three days of unemployment. (Second Schedule.) Under the existing Acts the waiting period is six days. The Labour Party tried to have it abolished altogether, so that benefit might be paid from the first day of unemployment, and they succeeded in carrying an amendment to that effect in committee, but as this and certain other amendments made in committee would have rendered the Bill insolvent the Government's concession of a reduction from six to three days was accepted on the Report stage. The amount of benefit payable for each insured person is limited to fifteen weeks' benefit in each insurance year and is not to exceed one week's benefit for every six contributions paid; but different limits may be prescribed later. (Second Schedule.)

A good deal of controversy occurred with regard to Section 8, which sets out the cases in which insured contributors are disqualified for unemployment benefit. The disqualifications in the Act of 1911 are substantially re-enacted. An insured contributor who loses his employment through misconduct or who voluntarily leaves his employment without just cause is to be disqualified for a period of six weeks, but the "Insurance Officer" may reduce the period in particular cases. The controversy took place over the provision that an insured contributor who has lost employment by reason of a stoppage of work due to a trade dispute at the premises at which he was employed is to be disqualified for unemployment benefit so long as the stoppage continues, unless he has in the meantime become *bona fide* and regularly employed elsewhere, but that where businesses or branches of work which are usually carried on in separate premises are carried on in one establishment, in separate departments, each department is to be regarded as a separate factory, so that a stoppage due to a trade dispute in one department will not necessarily disqualify the workers in the other departments.

The Labour Party maintained that a man who was not on strike and whose interests could not be affected by the issue involved should get unemployment benefit when out of employment owing to a dispute between other people. This sounds plausible enough, but it would often be difficult to say exactly which of the workers laid idle on account of a strike would be affected by the result; for a concession given to one section of workers has frequently to be extended to others. Another point is that the Unions so often give each other financial support during a strike, and it might happen that members of one union, employed in an establishment, who were laid idle on account of a strike of their fellow workers belonging to another union, were drawing unemployment benefit while contributing, by means of a levy, to the funds of the strikers' union, and thus helping to prolong the strike. So long as the employers and the State contribute to the Unemployment Fund it is impossible, in fairness, to narrow the disqualification to those workers who are actually and openly on strike. The Minister of Labour stated that he knew of no better formula than that in the Bill, although he was prepared to consider a better one if it could be found and it it were workable. It is understood that informal conferences took place between representatives of the Labour Party and representatives of employers on the subject, but without any definite result.

The Act provides for certain classes of disputes being decided by the Minister of Labour, subject to an appeal to the High Court, such, for example, as disputes as to whether any particular employment falls under the Act (Section 10); but in most cases claims for unemployment benefit and questions arising out of them are to be determined by "insurance officers," courts of referees and umpires. (Sections 11, 12 and 13.) In addition to a pro-

vision in Section 15 for temporary modifications in the rates of contribution and the rates or periods of unemployment, in order to secure the solvency of the unemployment fund, it is provided in Section 16, that with the sanction of the Treasury, the Ministry of Labour may revise the rates of contribution and benefit once every seven years, but the rates of contribution are not to be increased in all by more than 1*d.* per week from the employer and 1*d.* per week from the employed person.

The Labour Party's proposal for the equalisation of contribution and benefit between men and women raised a vexed question; but it has been provided that if such equalisation appears desirable to the Minister at any time after the expiration of three years from the commencement of the Act he may, with the sanction of the Treasury, revise the rates. (Section 16.)

The Act provides, in Section 17, for the administration of unemployment insurance by trade unions, friendly societies, &c. The admission of friendly societies to this was carried in committee despite the opposition of the Government and of the Labour Party, who maintained with much force that friendly societies, although well adapted for dealing with health insurance, had neither the experience nor the organisation for dealing with questions of employment and of insurance against unemployment. As a safeguard it is provided that before a society or other association is allowed to administer unemployment benefit under the Act the Minister must first be satisfied that it has an effective system of ascertaining wages and conditions and giving and getting notice of vacancies; but it seems clear that the admission of friendly societies into the administration of the Act will inevitably bring them into competition with the trade unions, and may even tend to convert them, to some extent, into trade unions.

Another section which has been much discussed is Section 18, which enables particular industries to "contract out" of the Act by setting up special schemes of unemployment insurance. These schemes must be made by a Joint Industrial Council or Association of Employers and Employees, and must have the approval of the Minister, and the benefits must be not less favourable than those provided by the Act. Great hopes were raised that the employers and the trade unions in particular industries would be encouraged in this way to set up generous schemes of insurance which would help to allay the fear of unemployment and thus contribute to the removal of industrial unrest, but there has been much disappointment at the meagre contributions to be made by the State to such schemes. These are not to exceed three tenths of the amount which would have been payable by the State under the Act—for example, the State will contribute 2*d.* in respect of each man insured in the ordinary way under the Act, but under a special scheme the maximum contribution would be practically six-tenths of a penny, which might not do much more than cover the cost of the administration of the scheme. The Government are apparently apprehensive that the industries with a low rate of unemployment may contract out of the Act, leaving the general unemployment fund to carry the burden of those which have a high rate of unemployment. Whether this apprehension is justified or not it seems likely that the low rate of the State's contribution will tend to discourage the setting up of special schemes.

Many employers have been disappointed at the omission from the new Act of the existing provision for the periodical repayment to employers of 3*s.* in respect of each workman for whom forty-five contributions have been paid during one insurance year; but the Government's reply to representations on the subject has been to the effect that there are only 20*s.* in the pound and that if these refunds are to be made out of the unemployment fund the contributions to the fund would require to be increased. It is perhaps not quite consistent with this attitude that the provisions in the earlier Acts for the repayment in certain cases of part of the contributions by employed persons who have reached the age of sixty years have been substantially re-enacted. Altogether it is evidently desirable that employers generally should read and study the provisions of the Act.

ROAD PROBLEMS.

It is a commonplace that the return of traffic to the roads, consequent on the introduction of the motor, found our highways incapable of withstanding the strain imposed on them, and demonstrated the necessity of extensive schemes of resurfacing and reconstruction. The rapid growth of road traffic during the past decade will now receive an additional impulse owing to the recent increase in railway rates and charges; and road costs are likely to be substantially increased accordingly. As a set-off to the burden thus threatening it may be observed that under present-day conditions, it is all to the good that the nation should have at its disposal alternative systems of transport. A monopoly under the control of capital can without difficulty be prevented from becoming unduly onerous, though some of the steps taken in this direction in the past have not in all cases been judicious. When, however, the control of a monopoly is assumed by organised labour, which is less amenable to regulation by law, there is a serious danger that the situation may be exploited to the injury of the public either in its corporate or private capacity. Indeed, we have already had instances of this, since although the railway companies are rightly and properly barred by law from discrimination between their customers, the employees' claim the right to refuse to handle goods addressed to unpopular firms. No doubt some remedy for such an abuse of power will ultimately be found, but in the meantime the difficulties arising from such a denial of "justice and right" can be much diminished by the further development of road traffic. Some instructive figures as to the value of this alternative means of transport were submitted by Major W. L. Gibson to the Dundee meeting of Institution of Municipal and County Engineers. A traffic census taken under Major Gibson's direction showed that during the railway strike last year the road traffic over a certain section of the Great North Road in Perthshire was fully five fold the normal, and would undoubtedly have risen far beyond this figure had the strike continued.

The return of traffic to the roads and the consequent greater wear of the latter has been coincident with large increases in the cost both of materials and of labour. It is unlikely and in some cases undesirable that there shall be any substantial diminution in the rate of wages now paid to road men. Hence the sole prospect of keeping down road costs to a reasonable figure lies in the better utilisation of the more highly paid labour. An interesting instance of what can be accomplished in this way was brought forward by Mr. James Lang, County Road Surveyor for the Kilmarnock District of Ayrshire. He stated that good road metal was only half the price in America that it was here, although higher wages were paid in the States. This has been effected by the adoption of mechanical devices for handling the material at the quarry, and by the introduction of very massive crushing machinery. Some of these American machines had, it is stated, jaws measuring as much as 7 ft. by 6 ft. Such machines can break 500 tons per hour. An American plant of this type, but with a smaller crushing machine, having, however, jaws measuring 54 in. by 42 in., is he stated now being erected in Scotland, and is expected to effect substantial reductions in the present cost of road metal. Of course only a large undertaking can afford to provide itself with plant of this character, and many of our quarries are small. Matters, we believe, are even worse in France, where it has been the policy of the road authorities to give out all contracts locally, and for short periods of time. The result there has been that the contractors are small men with little capital and compelled, in view of their short term contracts for small supplies, to sink as little capital as possible in their undertakings.

Amongst other labour-saving schemes discussed at the meeting was the plan of conveying tarred stone in steel containers, each holding 25 cwt. These containers are to be carried to their destination by 5-ton steam wagons, fitted with a crane driven by gearing from the engine. It is admitted that the total weights to be handled will be increased by perhaps 20 per cent., but on the other hand there will be a great saving in the time taken to load and discharge. Hence it is maintained that the wagon will make easily six trips a day in conditions in which it is now difficult to secure four. Moreover, the work of loading and unloading tarred stone by hand is far from popular, and there is some difficulty in getting men to undertake it.

In Major Gibson's paper already referred to particulars are given of a series of experiments made with different road materials on successive sections of the Great North Road at Dunblane. The length of road chosen was divided up into eight sections, which were surfaced as follows:—

Section No. Character of Surface.

1. Ordinary macadam.
2. Ordinary macadam surface tarred.
3. Macadam grouted with pitch and sand.
4. Macadam grouted with pitch and oil.
5. Macadam grouted with tar and Trinidad bitumen epuré.
6. Tarred macadam, *i.e.*, tarred material surface sealed with distilled tar.
7. Tarred macadam, *i.e.*, material tarred with two parts of tar and one of Trinidad asphalt epuré.
8. Tarred macadam, *i.e.*, tarred material surface sealed with Mexican bituminous mixture.

The results observed with these different materials and methods of construction show that ordinary macadam as used for section No. 1 is entirely unsuitable for main road traffic. It cost 12·39*d.* per yard super to lay (pre-war prices) and 3·92*d.* per yard super to maintain for five years, but it was practically worn out in 4 years 9 months. Section No. 6 was the best of the lot and stood alone. It cost 20·72*d.* per yard super to lay (pre-war prices) and the cost of maintenance for five years was 11·56*d.* per yard super. It was tar painted in 1916, 1919 and 1920.

In a note on road rolling contributed by Mr. W. Ballantine, Road Surveyor for East Stirlingshire, highly favourable mention is made of the motor road roller, which is said to be specially well suited for use when roads are being resurfaced with tar macadam, which is a material that does not require heavy rolling. Amongst other advantages claimed for it is a saving of time in starting up in the mornings, since with the engines in order a start should be made with one turn of the handle. The starting is in fact so easy that the engine should be stopped when the roller has to wait on the road. A supply of paraffin sufficient for two or three weeks can be carried in the covered van. With these rollers, moreover, provision is made for varying the load by ballasting one or both of the rolls. No insurance or inspection of boilers is required as with steam, and when the engine does wear out it can be replaced at less than the cost of fitting in a new firebox to its rival. In pre-war times with petrol at 1*s.* 3*d.* a gallon and paraffin at 8*d.* a gallon the running costs were much less than with steam, but at present prices, with petrol at 3*s.* 8*d.* a gallon and paraffin at 1*s.* 11*d.* a gallon, the fuel cost is about the same as it is with a steam roller using coal at 32*s.* a ton. On the other hand, the motor roller retains the advantage that its fuel involves less handling and that supplies sufficient for many days can be carried. Mr. Ballantine adds one word of warning in regard to the use of motor rollers. They must be kept on hard ground, as if a motor roller gets on to soft ground it has not sufficient reserve of power to extricate itself.

THE FOREMEN AND INDUSTRY.

Much has recently been written in regard to the position of the engineering foremen in the scheme of industrial organisation at the present time, and we have before us copies of a series of papers on the subject of "Shop Management from a Foreman's Point of View," which were awarded prizes in a competition scheme inaugurated by the Glasgow and West of Scotland Association of Foremen Engineers and Draughtsmen. Very considerable attention will, no doubt, rightly be directed to these expressions of opinions by foremen on the vital question of "Shop Management," and an analysis of these three papers gives scope for considerable thought. In passing,

it should be mentioned that to this association is due great credit for their initiative and organisation in inaugurating this excellent scheme. The mass of literature which is now available on the subject of "Shop Management" is generally greatly reduced in value by the knowledge that the exponents are more expert in producing technical literature than engineering manufactures, whereas these three papers under notice are written by foremen engineers, and the subject is treated from the view-point engendered by their daily work. The writing of such papers by foremen is greatly to be encouraged, because it must be the experience of everyone who attempts such a task, that the undertaking entails more intense and consecutive thought with the consequent development of ideas, than is possible in any other way.

The standard of the three papers, for which prizes were awarded, is of a high order, and it is understood that the less successful were hardly less meritorious. On the other hand, in view of the generous nature of the prizes—first, second and third being 30*l.*, 20*l.* and 10*l.* respectively—it is subject for very considerable surprise and regret that only six papers were submitted, and this from a district such as the West of Scotland, where engineering and shop management might almost be said to have had their inception. For engineering products the district, too, is one of the most important in the world. It is to be hoped that next year the support given to the scheme by way of numbers of papers submitted will be more representative of the skill and talent undoubtedly to be found amongst the members of this representative association.

To turn to the subject matter of the three papers published, they will be found to have a considerable amount of matter in common. All enter a plea for the consolidation of the position of the foreman in his increasingly difficult task of maintaining discipline, production, and a high standard of efficiency in the shop methods. Works' managers should make every endeavour not to increase these difficulties but rather to induce that measure of efficiency and team work which can only result from harmonious working. Promotion, so far as possible, from the ranks, is keenly advocated as a measure, giving incentive to the more ambitious in the shop to strive for promotion. We do not think that this point requires any emphasis, since, whenever at all possible promotion is surely so made in the great majority of cases. That the duties of foremen upon their appointment should be more closely specified than is the case at present, is suggested. The plan of the American type of organisation where the functions of every link in the chain are definitely laid down, irrespective of the nature or the capacity of the individual appointed to that particular post, has distinct disadvantages that hardly require enlargement. Much more depends on the type of management, and on the support given generally to the position of foreman.

The second point of moment, and at the present time of very considerable interest, is that it is now realised that the duties of the foreman with expanding organisation, and the demands for intensive production under the conditions of the shorter working week, must to some extent be subdivided. His position should be consolidated by expert assistance from separately controlled departments whose functions concern rate-fixing, planning of work ahead, and progressing of the work in course of construction. This is a signal of certain and recent progress of thought. Those responsible in the past for the introduction of payment by results of the individual type of system where such time or price allotted to the given price or amount of work is carefully calculated and recorded by a ratefixer, know that one of the obstacles most difficult to overcome has been the foreman's prejudice against the entry of the ratefixer into his shop, and the inevitable subdivision of responsibilities resulting. In these papers there is no definite scheme set out for planning and progressing of work, since it is realised that the best scheme is that which most nearly meets the requirements of the particular organisation, plant and product to which it is to be applied. Scientific management as such, is neither condemned nor advocated in these papers, although naturally, referred to. The functionalising of the erstwhile individual duties of the foreman is a point in question.

The third issue to which special attention should be directed concerns the fixing of rates. These papers are in favour of payment by results, which is regarded as essential to the achievement of the maximum production. The first favours collective piecework on account of the possibility thereby of achieving the maximum good feeling and fostering the co-operative spirit necessary for efficient team work. The second, however, is equally strong on the merits of the Halsey system of premium bonus. Both realise that competent men are required for ratefixers, that guess work and "rule of thumb" will not suffice for the future, that rate-fixing requires too detailed and specialistic attention to be added to the duties of the already overburdened foreman. In one paper, staff training, efficiency clubs and works' suggestion schemes are keenly appraised. There are many other points to which reference might be made, but the principal ones have probably been indicated.

These papers form interesting reading, showing clearly the close attention which the foremen to-day are giving to the various problems concerning industrial progress and the possibility of improvements for the future. Their position in the chain of organisation forms one of the most important links, and the benefits of their association and competition in such spheres as are encouraged in Glasgow and the West of Scotland will assist industry in its broadest and best interests. A perusal of these three prize-winning papers suggests that instead of naming one subject about which so much can be written, that very general treatment is almost invited within the scope of a paper before such an association, and instead of keeping to the beaten track, an alternative of two or three subjects of a more specific nature might in future be given as more likely to produce a larger response.

THE ENGINEERING AND ALLIED INDUSTRIES OF CANADA.

INDUSTRIALLY the Dominion of Canada is still in its infancy. Little more than a decade ago the majority of people in this country and many of those resident in Canada itself looked upon the Dominion as a country whose sole interests were agricultural. Outside of the produce of its fields and orchards, its forests and its fisheries little was known of the resources of the Empire's greatest colony. Few realised the possibilities of its having a great industrial future. And yet it is, perhaps, not too broad a statement to say that in the years to come Canada's prosperity may be as dependent upon the products of her factories as upon those of her land.

Up to 1914 the engineering and allied industries of Canada were, for practical purposes, insignificant. There were, it is true, a few shipyards on the Great Lakes and the St. Lawrence River, and on the coasts of Newfoundland, Nova Scotia, New Brunswick and British Columbia. There were a few steel works and general engineering shops in the cities of the eastern Provinces, and some rather important railway works. But six years ago the Dominion could boast of no concern in the engineering or allied industries of real magnitude, while the total output of all her works and shipyards was, from the view-point of national economics, of little real significance.

Up to the outbreak of the war Canada was an importer rather than a producer of engineering products. The vast bulk of her steel rails, much of her rolling-stock, almost all her structural steel, steel plates, agricultural and wood-working machinery, power and dock plant, machine tools and railway construction plant was purchased in the United States or in this country. Compared with her imports the output of her own factories was almost negligible. And yet in spite of their relative unimportance the works and shipyards which were in operation in the Dominion in 1914 formed the nucleus of an industry which promises eventually to attain a very considerable magnitude.

With the outbreak of the war a sudden and much-needed stimulus was given to the engineering trade of Canada. The insistent demand created by war conditions for all metallic and chemical products lead to a vigorous and sustained activity in works and factories throughout the country. To cope with this demand existing plants were extended and new plants were brought into being. In a very short time the Dominion became an exporter as well as an importer of engineering commodities, and as time went on the volume of her exports increased materially. By the time the armistice was signed the engineering industry generally had attained a degree of development which it would not have achieved in two decades of normal progress.

With the cessation of hostilities the urgent demands upon the Canadian factories ceased. Orders on hand were cancelled wholesale, and as yet no normal peace demands had made themselves felt to fill the place of the war orders. The inevitable reaction followed. For a time many works were closed or partially closed. Output fell in quantity, and as the high prices paid by the belligerent governments no longer ruled, the value of output dropped to an even greater extent. Similar conditions ruled in a greater or less degree in this and in other countries, but there is no reason to suppose that they are more than temporary.

Already in Canada there is evidence of a revival. Many plants, now adapted to the conditions of peace production, are hard at work. Output is again on the rising curve, and there is good reason to hope that, once world conditions become more stable and international trade resumes something approaching a normal state, engineering in Canada will continue to develop satisfactorily. Compared with 1914 the productive capacity of the Dominion has materially increased, and to-day her technical activities have assumed a considerably enhanced importance from the national point of view. That in the future they will attain a very much greater prominence is the confident anticipation of every one who is familiar with local conditions.

Behind the industrial development which Canada has experienced in recent years, there are factors other than the abnormal circumstances arising out of the war. The natural resources of the country are known to be great, and are at present largely unexploited. Industry so far has touched only the fringe of the Dominion's latent assets. Of the water-power available for the generation of current for industrial purposes only a negligible proportion has been developed; existing mining operations are local, and have barely tapped the great mineral wealth of the country. With her almost unlimited cheap power and her extensive deposits of copper, nickel, lead, zinc and other valuable metallic elements; with the known existence of iron ores which have so far been scarcely touched and her immense supplies of low-grade coal, Canada's industrial future is assured.

To turn from future possibilities to existing activities, the present industrial conditions in the Dominion are, all things considered, satisfactory. The problems of reconstruction and of industrial reorganisation to meet the changed circumstance of peace production have been tackled with characteristic vigour.

Already the trade depression which followed the armistice has, to a great extent, passed away. In the iron and steel industries, important developments have taken place since the cessation of hostilities—one concern alone has installed a new plate mill with a capacity of 12,000 tons per month—and although during last year the total production of both steel and pig iron was less than in 1918, it is hoped that during the present year the record figures then established will be at least approximately equalled. In 1918 the total output was 1,195,500 short tons of pig iron and 1,875,708 short tons of steel. In 1919 these figures fell about 5 per cent. in the case of pig and over 40 per cent. in the case of steel, the latter due to the closing down of many furnaces on the cancellation of war orders. This year a number of these furnaces have again been put into operation, and a material increase in the output of steel is anticipated as a consequence.

Up to the present the chief basis of Canada's iron and steel industries has been imported ore. Beneficiated ores in relatively small quantities are obtained from the siderite deposits at Magpie and the magnetites at Moose Mountain, in Ontario.

The bulk of the ores used, however, are still largely imported. When the iron ores in other parts of the Dominion are more extensively worked this handicap to the industry will be largely overcome.

In point of value, copper is the most important metal mined in Canada. In 1918 the pyrites ores of Quebec yielded 5,869,650 lb. and the nickel-copper ores of Ontario some 47,100,000 lb. British Columbia produced nearly 63,000,000 lb. In 1919 the total copper production decreased by 25 per cent., a figure which will probable be materially improved upon this year, unless unforseen circumstances should arise. The potential production is immeasurably in excess of the present yields. Nickel ranks next to copper in point of importance, and the output is, for practical purposes, limited only by the demand. How much nickel is available in commercial quantities in Canada is a matter of conjecture, but there is certainly enough to supply the world demand for a considerable period. Owing to the decrease in the demand for nickel steel which was brought about by the signing of the armistice, the total production of nickel during last year approximated one half that of 1918. Other mineral products which are found in considerable quantities, and worked to a greater or less extent, are lead and zinc, cobalt, molybdenum, arsenic, asbestos, chromite, magnesite and graphite. During last year the output of all these substances, with the exception of asbestos, was less than the output of 1918. The production of asbestos during 1919 remained steady, and will probably be somewhat greater this year.

In 1918, the total output of coal for the whole dominion was about 15,000,000 tons, including Alberta lignite, the demand for which throughout the Prairie Provinces was stimulated owing to labour troubles in the mines of the United States. In 1919, there was a decrease of some 17 per cent., the falling-off being largely due to a considerable reduction in the amount of lignite mined. It should not be forgotten that, although Canada is a large importer of coal, and has practically no high grade steam coal of her own, she is very rich in bituminous coals and lignites, only the most accessible and easily worked of which have so far been exploited. Recent developments in the commercial distillation of fuel oils and volatile gases from low-grade coals may eventually invest the enormous lignite deposits of the Western Provinces with a commercial value they would not otherwise attain. As these deposits are, in many instances, thick and near the surface mining operation can be conducted with a minimum of expense.

The value of the mineral production of Canada during 1918 was about £43,000,000, and in 1919 about £35,000,000. This year the latter total should be materially exceeded. These figures, representing as they do the total yield of the mining industry in all its phases for a country the size of Canada, may not seem impressive. It should be remembered, however, that present mining operations have barely tapped the mineral wealth of the Dominion. So far only the most accessible and easily worked ores have been touched, and many of the existing workings have never been developed to anything like their full extent. With the gradual opening up of more remote parts by the extension of railway communications and the further development of deposits already accessible but not yet fully exploited, the mineral production of Canada may be increased to an extent limited only by the amount of capital and of labour available.

Some idea of Canada's industrial growth during recent years may be gathered from the fact that the amount of capital invested in industrial concerns increased 40 per cent. between the beginning of 1915 and 1917. Definite figures for the years subsequent to the latter date are not at present available, but it is estimated that to-day the total capital invested in the industries of the Dominion is probably nearly double that of 1915. A large proportion of this increase has been due to the development of the mining, engineering and allied industries. Another striking illustration of industrial expansion is furnished by the export of manufactured goods. In 1913 the total value of such exports amounted approximately to £11,500,000. In 1918 their value was £127,300,000. Part of this increase was, of course, due to the higher prices which ruled, as a result of war conditions. But even allowing for this, and for the falling off which has taken place since 1918, it is safe to say that the actual volume of such exports is at least four times as great to-day as it was prior to the war.

An aspect of the industrial expansion which may confidently be expected to take place in Canada during the next few years, and which should not be lost sight of by British engineers, is the demand which will be created thereby for plant and machinery of all descriptions. Dominion manufacturers will not be able to supply the requirements which the development of the country's industries and natural resources will entail. There will be a market for British engineering products covering a wide range. There is in Canada a strong tendency to favour British made plant which, if properly fostered, should be capable of yielding profitable results. But there is also keen competition from the United States, and if the British manufacturers wish to meet this successfully it will be necessary for them to make a careful study at first hand of local conditions and requirements, and to design with a view to filling such conditions and requirements. In many respects, methods in Canada differ from those in use in our country and what may be an excellent thing for Glasgow may not be nearly so good for Toronto. British manufacturers can supply everything which the Dominion's industrial developments will call for, and if they take sufficient trouble they can get a considerable portion, at least, of the business which will be going.

There is an excellent market already in Canada for machinery of almost every description, and as time goes on the market will improve. A little trouble and adaptability on the part of our home producers is all that is necessary to obtain for us a share, and probably the lion's share, of this business. It will prove worth going after.

NOTES.

Colloidal Solutions and Pig-Iron.

Water solidifies at 0 deg. C. The presence of salts in molecular solution lowers the freezing-point of the water by amounts which can be calculated in accordance with the gas laws. The presence of colloidal particles is not supposed to depress the freezing-point (Wolfgang Ostwald). Since molecular solutions are probably only colloidal solutions in extreme subdivision, one is rather inclined to doubt this statement, but we will not discuss that point. When a molecular solution is frozen in stages, the ice lumps, obtained at the different stages, should differ in their percentages of salt, and they do differ; in the case of colloidal solution there should be no such difference, apart from the fact that colloidal particles will move about and be deposited during the cooling. From this argument Waldemar Ostwald (*Kolloid Zeitschrift* of March last) concludes that it might be possible to decide, whether the various elements present in pig-iron and in alloys are contained in a molecular or in a colloidal solution, and he refers in this connection to some experiments by Osann and K. Wolf. They enriched a mass of 12 kg. of pig-iron with sulphur—how, is not explained—fused the pig and allowed it to cool very slowly, the process taking 12 days. They then analysed different portions of the lump of pig for their constituents, and they observed peculiar differences as to the distribution of the four chief elements concerned—sulphur, carbon, manganese, phosphorus. As regards sulphur the percentage decreased in a fairly regular way as they penetrated from the upper surface of the iron into the lower strata, the percentages of sulphur found being 0·47, 0·25, 0·10, 0·04 and 0·02. A fairly regular distribution in horizontal layers was also observed in the case of carbon, but the concentration changed in the opposite sense; the carbon percentages of the layers, proceeding from the top downward, were 2·9, 3·0, 3·2, 3·4. Manganese and phosphorus showed quite different arrangements. The top portion was richest in manganese, 2·19 per cent.; underneath this surface layer the arrangement was roughly in concentric shells, the core containing 1·99 per cent. of manganese, the shell surrounding this core on all sides 1·87 per cent., and the outer shell 1·70 per cent. of manganese. The distribution of phosphorus, though less regular, was somewhat similar to that of manganese, but again the concentration in phosphorus increased, instead of decreasing, from the core outward, from 1·64 per cent. to 1·84 per cent. Ostwald interprets these analyses as showing that sulphur and carbon were, at least partly, dissolved in the colloidal state, whilst manganese and phosphorus were present in molecular solution. The one experiment hardly justifies conclusions, and the cooling took place under exceptional conditions, of course. But Ostwald has other data, and the matter deserves investigation.

Transition from Coal to Coke.

Since coke is a conductor of electricity, whilst coal is not, it occurred to Mr. Eric Sinkinson to determine the change of resistance of coal during its carbonisation. The experiments form part of the coal research conducted in the Imperial College of Science and Technology, South Kensington, and are described in the July issue of the Journal of the Chemical Society. In assuming that the resistance would depend upon the particles of free carbon liberated during the carbonisation which would form a conducting bridge in a non-conducting medium, Sinkinson decided to pulverise and to briquet the materials. He took, in the first instance, coke (from Durham and from Wales), ground it, passed it through a 200 mesh, dried it at 105 deg. C., mixed it with 10 per cent. or more of pitch and briquetted the mixture by compressing it in a steel cylinder, 2·5 cm. in diameter, under a pressure of 31·5 kg. per square millimetre. For the resistance tests holes were bored into the ends of the briquettes and filled with mercury. The briquettes containing, 10, 50, 70, 80, 90 per cent. of pitch then gave resistances of 0·16, 0·64, 5·6, 71, 20,500, 500,000 ohms respectively; these figures refer to the Durham coke; the Welsh coke yielded practically the same figures. Sinkinson then coked various coals at temperatures of 900, 800, 700, 600, 550, 500, 400 deg. C. in silica tubes electrically heated for two hours; he then ground the coked material up as before, mixed it with 10 per cent. of pitch and briquetted the mixture; the addition of 10 per cent. of pitch had very little influence on the resistance, as the previous experiments had shown. Cokes carbonised below 700 deg. C. did not require any pitch as binding agent. In other experiments he heated the coal, into which he inserted platinum electrodes, between asbestos plugs in order to obtain continuous resistance records during the carbonisation period. Again, the Durham and Welsh coals and other coals as well, gave very similar resistance values, both at the high and the low temperatures. But the change in resistance and hence probably the transition of the coal into coke, took place at different temperatures, the temperatures at which decided conductance set in being: for Welsh coal, 500 deg. C.; Durham coal, 530 deg.; Spanish coking coal, 500 deg.; Spanish non-coking coal, 450 deg.; Silkstone coal, 500 deg.; in similar experiments made with some other materials electric conductance appeared in cellulose at 500 deg., in Yacca gum resin not below 640 deg., and in starch at 580 deg. As conductance was in most of the coals observed at about 500 deg. C., Sinkinson concludes that carbonisation, formation of free carbon, may be said to begin at that temperature, though decomposition takes place at much lower temperatures; since this same temperature of 500 deg. was also observed in cellulose, the formation of sufficient free carbon for electric conductance would seem to be due to the cellulosic constituents of coal.

The Manufacture of Explosives.

The forty-fourth annual report of H.M. Inspectors of Explosives, just issued, shows a large diminution in the number of accidents as compared with recent years. The figures are indeed back to pre-war values. In general the great majority of accidents with explosives occur in connection with their use, the precautions taken during manufacture, keeping and conveyance having proved very effective in minimising the risks of an inherently dangerous industry. During the period of the war, the output was of course enormously increased and the factories had for the most part to be operated with totally inexperienced labour. Nevertheless, in the worst year, 1916, the number of

persons killed by accidents occurring during manufacture was only about 15 times as great as in 1913: the respective figures being 195 and 13. In 1917, although more accidents occurred, viz., 404 in place of 363, the death rate was reduced to 54. These figures bear eloquent testimony to the skill and care taken by those in control of the factories. Last year the total number of accidents occurring in the manufacture of explosives was 65. The number of injured was 31 and there were 8 fatalities. The figures are highly satisfactory in view of the fact that a substantial proportion of the work done was the "breaking up" or unmaking of explosives, which is admittedly more dangerous than the making. In fact, 6 of the 8 deaths reported were attributable to "breaking up" operations. In the use of explosives there were 360 accidents, a figure which it is curious to note is much in excess of those shown in the returns for the war years. In these 360 accidents 48 people were killed and 469 injured. In the conveyance of explosives there was only one accident. In this case a motor lorry carrying incendiary bombs caught fire, but the bombs escaped and no one was injured. Until the war it was illegal to transport explosives by motor, but this regulation had then to be relaxed. The experience thus gained has shown that attendant dangers were overestimated and the temporary regulations permitting and regulating this method of transport have accordingly been made permanent. The report includes particulars of tests made on the sensitiveness of fulminate of mercury to percussion. This was found to diminish when the crystals of the fulminate used were finer. The sensitiveness of the detonators, however, was found to be nearly independent of the initial sensitiveness of the fulminate with which they were charged. The reason appears to be that in compressing the fulminate into the shell of the fuze large crystals are broken up so that the fineness of the fulminate in its ultimate condition is much the same whether the crystals at the outset were large or small. Other experiments showed that the charging pressure should lie between 600 lb. and 1,500 lb. per square inch, very bad detonators resulting with higher pressures. In counterweight controlled charging presses, the actual pressures attained were found to be much higher than the nominal, owing to inertia effects. A spring control has accordingly been devised, which is free from this drawback.

LITERATURE.

The Propagation of Electric Currents in Telephone and Telegraph Conductors. By J. A. FLEMING, M.A., D.Sc., F.R.S. Third edition, revised and extended. London: Constable and Co., Limited. [Price 21s. net.]

ALTHOUGH the title of this book would appear to limit its scope to a particular department of electrical engineering, its aim is more extensive. The treatise had its origin in a series of post-graduate lectures intended not only to place students in a position for solving electrical problems for themselves but to further the instruction and training of those, who will both disseminate acquired knowledge and create new avenues for research. It is true that the main object is to show the character of the improvements in the methods of telegraphy and telephony that have followed the discussion and analysis of the problem of the propagation of electric waves, but a similar treatment and a similar necessity for recurring to first principles occur in other problems that come before the electrical engineer. The method of enquiry is of quite equal importance to the results obtained, and when the sources of information are intelligently tapped, practical results of equal importance may be anticipated. If the form of the treatise had not been settled by previous editions but had been designed entirely afresh, the author might have attacked other problems connected with electric wave propagation, as for example, the passage of waves over a spherical earth as illustrated in radiotelegraphy, or the phenomena of wave propagation in long power lines. There are many problems awaiting exhaustive examination that demand both mathematical analysis and painstaking experiment, and the necessary qualifications are not often found in the same individual. A lamentable instance of the want of co-ordination between the work of the analyst and that of the experimenter is furnished, as Professor Fleming reminds us, by the neglect of the researches of Oliver Heaviside who determined the conditions that ensure the "distorsionless" cable, and thereby suggested the means for successfully developing long distance telephony. For five and twenty years the work of Heaviside lay neglected, or possibly admired as an academic exercise, but his latent suggestions had no practical effect, till they were re-discovered by Pupin and sent back to us as a brand-new American invention.

To provide against such unfortunate repetitions, the author would have his pupils understand the value of a mathematical formula and the depth of meaning that may lurk behind the symbols that are so distasteful to many. Accordingly, his first chapter is devoted to the explanation of vectorial notation and hyperbolic trigonometry. The steady increase of suitable tables for facilitating numerical calculations, when dealing with complex quantities, or hyperbolic functions, places in the hands of engineers a powerful weapon, whose use was denied to an earlier generation, and the number of distinguished physicists who have approved the process by adopting it, testifies to the merits and advantages of such special mathematical tools. Originality of treatment can hardly be expected here, but the several propositions are presented with a brightness and orderly sequence that reveal the hand of a master.

The second and third chapters are of great importance, bearing upon the general theory of wave propagation with special reference to the behaviour of electromagnetic waves. The subject of wave motion in an elastic medium is treated at length, and the derivation of the general differential equation for wave motion is effected in a novel manner. Electric and magnetic forces and fluxes are rather briefly handled, but sufficiently, remembering that a class of engineers and experts is being addressed. Several important definitions as vector impedance and admittance are introduced and explained, while the discussion of the wave length constant and "attenuation constant" opens up the road to that great desideratum of the electrician, the "distortionless" cable.

The practical portion of the work begins with the study of the propagation of a simple periodic electric current in telephone cables. Several special cases are considered as that of an infinitely long cable, and of lines of finite length, either free or insulated at the receiving end, and again varied by short circuiting or the insertion of an instrument of known impedance. This last is the practical telephone problem, affording opportunity for applying the formulæ already derived. Having given the specific qualities of a cable which are summed up in the resistance R, the inductance L, the electric capacity C, and the insulation conductivity S, and with the known impedance of the receiving instrument Z, across the line at the receiving end, it is required to calculate the current and voltage at any point of the line, when a simple periodic electric motive force V is applied at the sending end. That such a problem should be soluble is highly satisfactory, for the solution demonstrates the possession of a consistent electric theory, and indicates the possibilities of improvement and the limitations inherent in the method.

The theory of wave propagation of an electric current in a telephone wire shows that the shorter the wave length the greater the velocity of travel, and the more rapid the attenuation in amplitude. Hence the different harmonic constituents, representing any syllabic sound, travel at different speeds and attenuate at different rates as they move along the line. The attenuation factor may be disregarded, as being of much less importance than the phase factor, for the sound is not lost from feebleness but from want of clearness of articulation due to distortion in the arriving waves, a defect that grows more intolerable with the increase of the length of the line, till finally practical telephony by wire breaks down. Electric waves transmitted through the ether as in radiotelephony, all travel with the same velocity, hence there is no distortion in the wave form, or limit imposed on this account. There may be other difficulties to tax ingenuity, but at present the propagation of electric waves through condensers is the only point under consideration, and the interest centres in determining how far theory will assist the practical man in devising remedies that will extend the radius of distinct telephony. It is the triumph of mathematical investigation that theory in the hands of Mr. O. Heaviside has clearly disclosed the conditions that render long distance telephony feasible. He established the fact, that more nearly the product of C R equalled that of L S (using the notation already explained) the more closely would waves of all wave lengths travel with the same velocity and attenuate at the same rate. The equation shows that there is an ample choice of methods by which improvements may be effected. Some electricians have diminished the resistance by using high conductivity copper cables. Professor Sylvanus Thompson suggested increasing the leakage, by providing the cable with induction leaks. Other proposals have been made, but apparently the most economical plan and the one favoured by Heaviside, and subsequently practically applied by Professor Pupin, consists in increasing the inductance by loading the cable with coils of wire inserted at equal intervals.

The method is applicable to aerial lines and both underground and submarine cables, and in actual practice it is found that the attenuation is reduced to less than one half that of the unloaded cable. In the case of the submarine cable, some practical difficulties have to be overcome since the insertion of bulky, heavy iron-cased coils, is impossible. A method of uniform loading may be adopted, in which the copper conductor is inclosed in iron wire but if the Pupin form is preferred, the coils must be of such a form that the increase in diameter is not too great to prevent the thickened cable being paid through the gearing or sheaves of the cable ship, without injury to the coils themselves. The problem was solved successfully in the case of the Anglo-French cable of 1910, and similar devices were employed in the case of the Anglo-Belgian a year later, but it is somewhat disappointing to find that little progress has been made since. The latest coil loaded submarine telegraph cable is that across the Irish Channel, 64 nautical miles in length, which was put down in 1913. This is the longest loaded submarine cable working, but whether the further development has been stayed by the improvements in wireless telegraphy, or by the exigencies of the great war does not appear. Progress, however, has not been stopped by the want of an adequate theory.

In the case of aerial lines there is no difficulty in inserting the load coils in the run of the cable, though their efficiency is diminished by the varying value of S/C due to change of insulation caused by leakage over the porcelain insulator. With underground wires the induction coils may be conveniently placed in pits at intervals of two or three miles, and the efficiency should be more constant. Judged by length of distance, the device of loading has been very successful on land, notwithstanding loss due to attenuation. The longest loaded aerial line in use is that of New York to San Francisco, completed in 1916. The line consists of a pair of metallic circuits carried on wooden posts throughout the entire length of 3,400 miles. At intervals in the line it is found necessary to insert telephone repeaters to boost up the attenuated current. Further details of these boosters would be welcome, but it is understood that the principle of the thermionic valve is utilised. A feature of great practical importance is the formation of the so called "phantom" circuit, which permits two pairs of lines not only to be employed for three conversations simultaneously, but the four separate copper conductors can be used as telegraph wires, and each of these can be duplexed, permitting the transmission of four telegraphic messages in each direction. This economy is possible from the manner in which the wires are fixed, each being rotated round the other so as to prevent mutual induction. The two lines forming the lead and return of one circuit are employed in parallel as the lead of a third circuit, and the two wires forming the second circuit can be utilised as the return of the "phantom" circuit,

when transformers, having a middle contact in the transformer coils of the two side circuits are introduced so as to connect the "phantom" circuit to receiving and transmitting instruments. The "phantom" circuit can be separately loaded with induction coils, and by virtue of the lower copper resistance of this circuit proves admirably adapted for the transmission of articulate speech. Another successful loaded cable is that from Berlin to Rome, but in the limited space available in this country, our longest example is that from London to Leeds, 189 miles.

In following or rather in indicating the connection between the theoretical work of Mr. Heaviside and its eminently practical application to the purposes of telephony, no attempt has been made to exhibit the completeness with which Professor Fleming has discussed the subject, or the convincing character of his demonstrations which add so much to the value of the treatise. In this connection reference might be made to his treatment of the problem of reflection losses at junctions between overhead and underground lines, and of the methods of electrical measurement and the constants of cables, matters that interest the electrical engineer and in which the accuracy attained is in no small measure due to the use of instruments that the author has invented or improved. The results of the comparison of theory with experiment should inspire confidence, both in the accuracy of analysis and the competency of manipulative skill. Of particular interest, is the use of mechanical devices to illustrate an analogy such as that existing between the transmission of mechanical vibrations along a loaded string and the propagation of alternate electric currents along a telephone cable having inductive coils inserted at equidistant intervals. Similarly, one cannot but admire the ingenuity displayed in the construction of apparatus designed to render evident stationary electric oscillations on helices of wires. Such assistance is always illuminating.

The Field Manual. A Practical Treatise of Surveying Methods and Operations, embodying Field Problems for use in Surveying Courses in Colleges and Universities. By Arthur Lovat Higgins, B.Sc., A.R.C.S., A.M.Inst.C.E. London: Sir Isaac Pitman, Limited, 1920. [Price 21*s.* net.]

Of the making of books on surveying there is no end, suggesting that each training centre desires to have its own manual. Mr. Higgins presents the most recent addition on the ground that the treatment of the art of surveying is arranged with particular reference to the training of civil engineers and to meet the demands of modern practice, but very similar words might be found in the prospectus of many works recently issued on the subject. As the purpose is similar, so must the contents be. The subject is a small one, and the authors are confined within very narrow limits. For the acquisition of the requisite facility of manipulation of instruments and the derivation of results with speed and accuracy, teachers may recommend different methods of using the information supplied, but the theory of the chain and the level, of the theodolite and the sextant, remains unaltered. The author favours the holding of periodic classes of short duration throughout the session at which detached problems and exercises can be practised, and the formation of survey camps for the study of connected schemes more comparable with the details necessary in actual projects. This programme so nearly coincides with that ordinarily followed in this country, that it possesses little novelty and offers little assistance to teachers and professors. The author has apparently had much practice in American methods, and anticipating that his pupils may have similar experience, describes various schemes more generally used in that country "the text being interspersed with a number of common synonyms," which occasionally are not without a sense of liveliness.

The book, which contains some 900 pages, is divided into nine sections, each of which refers to some particular instrument and the class of observation for which it is fitted, or to the office work of the surveyor. Thus sections are allotted to the chain, the level, the theodolite, with an additional division on the solar attachment, the tacheometer, the sextant and the compass. Topography, the construction of contours, calculation of areas and of volume of earthworks come under other sections. Mining surveying and photometrical surveying are mentioned in the introduction, but do not come within the scope of the work, and hydrographical surveying is treated very briefly. The general plan pursued in each section consists in describing the principles and construction of the instrument with the more important variations it has undergone to increase its convenience, its utility, or its accuracy. Next the method of use is described under conditions which are likely to occur in practice, with numerous examples or problems which the class may work out under supervision, the description winding up with some practical hints and observations that may be of use in the field to those who are working without personal instruction. The remarks on the amount and sources of error likely to be encountered might be profitably extended.

The description of most of these instruments and their method of use follows the usual lines, and calls for no remark, but the "Solar Attachment," is, we imagine, an American device that does not find any wide application in this country. The description of this auxiliary piece of apparatus is not easy to follow, perhaps because we have failed to grasp exactly what is meant by "a solar lens casting an image of the sun," but the object is clearly expressed. With it an observer can determine "directly by solar observation (*a*) the true meridian; (*b*) the latitude; and (*c*) the hour of the day. It mechanically enables him to solve the astronomical triangle." Is there only one astronomical triangle? The problems given as examples to illustrate its use can be, and generally are, solved by the use of the theodolite and sextant. The solar attachment has the appearance of a rather clumsy excrescence and cannot be trusted to give results of a very accurate character. No complete theory of the instrument is given, and, consequently, the nature of the errors cannot be determined, and no arithmetical correction to remove these errors can be applied. The equation of time is not alluded to in reducing the observations of the sun, and the corrections for refraction are computed in a very inaccurate manner. The introduction of astronomical observations should increase the accuracy of the results, but reliance on the solar attachment would not have that effect.

The theory of the tacheometer is not given with the fulness desirable, but the stadia tables for the reduction of inclined sights to horizontal distances and the corresponding vertical components may prove useful, and enable the student to get rapid results independent of theory. Some additional remarks on contouring with the tacheometer will be found under the article on the plane table, but the division is not altogether satisfactory. On the other hand, the author seems very familiar with compass surveying, and apparently he gets the utmost possible out of this instrument, and generally the book seems more useful to those engaged in preliminary surveys than on rigorous, accurate work, though in saying this, we do not forget that the methods of measuring a base line and other delicate operations are described. It is undoubtedly a difficult task to preserve the same limits of accuracy throughout many different operations.

Ions, Electrons and Ionising Radiations. By James Arnold Crowther, Sc.D., sometime Fellow of St. John's College, Cambridge. London: Edward Arnold, 1919. [Price 12*s.* 6*d.* net.]

In the last quarter of a century the science of physics has advanced by leaps and bounds, new horizons have opened out offering avenues for research, that will have to be explored by a machinery whose capacities were unsuspected and possibilities unknown a generation since. The startling discovery of the Röntgen rays, the phenomena of radio-activity, and the disclosure of the true character of the cathode rays stimulated research, and excited general interest. When the facts were few and isolated the public showed great anxiety to master them, but much of that eagerness disappeared as the novelty wore off. Though the harvest of facts grows richer, the exhibition of intelligent curiosity is missing, for the mental effort required to weigh evidence and draw correct inferences from nicely-devised experiment is of a different order from that which is pleasantly excited by the announcement of a curious and unexpected discovery. The power to follow a sustained argument drawn from distinct sources, and to trace a logical connection throughout, constitutes, however, the real educative value of the research, which has been prosecuted with such brilliant success, and in this country especially at the Cavendish Laboratory under the inspiring influence of Sir J. J. Thomson. Progress has not been along one line, but several, and there is great need to weld the separate but parallel lines of investigation into a consecutive, unbroken chain. The author has set himself the task to co-ordinate the results, to trace the linkage that connects the argument and gives it increased coherence, and to exhibit the position that has been won and the strength of the foundation on which it rests. This task he has performed with skill and judgment. He is writing mainly for students who have been grounded in the more elementary portions of physics and desire to acquire a systematic knowledge of its latest developments. But the work is one that can be read with pleasure and consulted with advantage by all who are intelligently interested in the subject, for the mathematical treatment has been simplified and can be easily followed. The author holds the opinion, in which he will meet with general support, that a better understanding of the argument "and of the physical principles involved in it is more readily attained if the mathematical analysis is not too complicated."

The general plan of the book proceeds by the description of experiments, involving the setting up of apparatus and the examination of the conditions that best secure accuracy or avoid systematic error. The material for selection is large, bewilderingly large, and Dr. Crowther has naturally chosen for description those researches that best illustrated fundamental and important theories, arranging these in the sequence which his experience at the Cavendish Laboratory has taught him was best adapted to the requirements of the student. The theory underlying, or the interpretation of, each experiment is made clear, and the inferences drawn from the established facts logically stated. An arrangement that would unfold the history in regular order is rendered difficult by the want of uniformity in progress, due in a great measure to a number of brilliant experimentalists attacking the same question simultaneously by different methods. The relation between these methods is not always evident, as, for example, Perrins' work prompted by a consideration of the Brownian movement and Millikan's classical experiment for the determination of (*e*) the charge carried by an ion. Yet in many cases, the approximate identity of results, if it does not advance the development, greatly strengthens the conclusions and gives support to the theory the experiment was intended to elucidate. Some repetition or examination from different points of view is therefore necessary.

The tale is a long one and a marvellous, needing a master hand to conduct us through its subtleties. It begins with the discovery of Sir William Crookes that the passage of an electric charge through a vacuum tube was accompanied by a type of radiation which moved in straight lines, but could be deflected by a magnet. In spite of much hostile criticism, Crookes maintained that these cathode rays as they are now called, were due to a very attenuated form of matter, and this opinion was triumphantly vindicated when some twenty years later Sir J. J. Thomson demonstrated that the rays consisted of negatively charged particles, travelling with a high velocity, depending on the difference of potential across the terminals of the discharge tube. Other known phenomena of which adequate explanation was wanting were found to be connected with these particles or electrons. Ultraviolet light falling on a metal plate produced them, and they are given out freely from an incandescent body. Radio-active bodies emit them spontaneously, and the conclusion is irresistible that the electrons form part of the atoms of matter from which they can be released by a variety of agencies.

Radioactive bodies, however, emit other radiations whose study has been specially fructiferous. One

form known as the α rays consists of atoms of helium that have lost two electrons, and consequently possess a positive charge. Another class, the β rays, carry a negative charge, and are identical with the cathode rays, only differing from them in velocity. A third group, the γ rays, are described as pulses in the ether of very short wave length but the ether is a somewhat discredited body now, and it is difficult to know what particular meaning is attached to the term, but there seems to be little ambiguity or inaccuracy in describing these as ultraviolet rays of extremely short wave-length. They are separated by a long interval from the ultra-violet rays, whose effects can be perceived in the laboratory, but a link connecting the two is to be traced in the fact that both are able to produce conductivity in a gas.

These rays form not only an object of investigation, but give the physicist the hope and the means for unravelling the mechanism of the atom, and of solving the fundamental problem which lies at the bases of physics and chemistry. Very cunningly has the physicist used the tools with which he is supplied. One knows not whether to admire the more the ingenuity with which they have been used, or the success that has attended their use. A bare catalogue of results would occupy much space, to render justice to the skill with which experiments have been conducted, or the originality of thought that suggested those experiments, is impossible.

The success of Sir J. J. Thomson in demonstrating the true nature of the Crookes radiation has already been mentioned. The consequences of that research were far-reaching, for it taught that the atom is an electrical system of greater complexity than Larmor or Lorentz had conjectured, and further showed that the general features could be pictured with great probability. We are on safe ground in assuming that the atom consists of negatively-charged electrons, coupled with a positive charge sufficient to maintain neutrality, when ionisation by the emission of an electron is absent. The number and arrangement of these electrons in an atom is at present undetermined, but there is much evidence to show that the number is equal to the "atomic number" of the element as determined by the "periodic law." The arrangement within the ample space provided by the confined limits of the atom is a matter of conjecture. Inquiries into the character of the positive charge have not been quite so successful. All attempts to prove the existence of a "positive electron" of small mass, the counterpart of the negative electron, have resulted in failure, and probably the positive electron in this sense does not exist. Certain it is that a unit of positive electricity has not been found associated with a mass less than that of the hydrogen atom. The position and distribution of the positive unit throughout the atom is of course equally unsettled. Its mass may be scattered throughout a sphere comparable in size with the sphere of action of the atom itself, or it may be concentrated in a very minute nucleus containing the greater part of the mass of the atom. This latter view is perhaps better supported by the greater amount of evidence and recommends itself by the ease with which the mechanism can be imagined, resembling a solar system in miniature. The phenomena of radio-activity seem to require the presence of electrons in this nucleus, but a likely arrangement is for the electrons to constitute definite rings round a central nucleus, recalling the formation of the planet Saturn and its ring system. In such an arrangement of rings, it is curious to notice, that mathematical analysis indicates that a ring of electrons, as conceived, revolving in one plane, will not be stable, unless it contains a certain minimum number of electrons. Accordingly, rings containing a certain number of electrons alone are possible, and the interruptions or the places where the formation of new rings occur, correspond to similar interruptions in the table of Mendeleef. Whether this is simply a coincidence, or an indication of a general law, profoundly affecting chemical properties cannot yet be decided. Greater confidence has attended the research that has identified the negative electron with the β particle emitted from radioactive bodies, and has confirmed the suggestion, that the whole mass of the electron is electromagnetic in nature and is due simply to the charge which it carries.

Having formed a possible model atom it is inviting to inquire to what extent the mechanism would work when submitted to the conditions of experiment. Would it, for example, account for the phenomena exhibited by the spectrum and the so-called Zeeman effect? Will the simple arrangement of one electron assigned to the hydrogen atom be sufficient to explain the comparatively complicated character of the spectrum of that element? Does it throw any light on the somewhat obscure law of Planck and show why an interchange of energy between radiant energy and matter cannot take place continuously, but only in definite units to which the term "quanta" has been applied? Is the cunningly devised machinery sufficient to explain the disruption of the chemical atom by a spontaneous and uncontrollable process as witnessed in the phenomena of radio activity? It would be very attractive to discuss these problems, and especially the possibility of transmutation of elements and the chances of creating new matter under experimental conditions, but such questions demand far more space than can be given to them here, and further they are at present of too speculative a character to be worth discussing.

BOOKS RECEIVED.

Bridge and Structural Engineers' Handbook of General Specifications, Formulæ and Data for the Design of Cranes, Bridges, Foundations and Workshop Buildings. Embodying the Practice of Sir William Arrol and Co., Limited. By ADAM HUNTER, M.Inst.C.E. London, E. and F. N. Spon, Limited, 57, Haymarket, S.W. 1. [Price 21*s.* net.]

United States Geological Survey. I: 28. *Lead in* 1917. *General Report.* By C. E. SIEBENTHAL. Bulletin No. 711. *Contributions to Economic Geology (Short Papers and Preliminary Reports)*, 1919. Part II. *Mineral Fuels.* By DAVID WHITE and J. H. ASHLEY, Geologists-in-Charge. No. 711-H. *Anticlines near Maverick Springs, Fremont County, Wyoming.* By A. J. COLLIER. No. 716 A. *Geology of Alamosa Creek Valley, Socarro County, New Mexico, with Special Reference to the Occurrence of Oil and Gas* By Dean E. WINCHESTER. No. 716 B. *The Upton-Thornton Oil Field, Wyoming.* By E. T. HANCOCK. Washington: Government Printing Office.

Who's Who in Engineering, 1920–21. Edited by JOHN ED. SEARS, C.B.E., M.A., Assoc.M.Inst.C.E. London: Compendium Publishing Company.

Twelfth Annual Report of the Hydro-Electric Power Commission of the Province of Ontario for the Year ended October 31, 1919. Vol. I. Toronto: A. T. Wilgress.

Notes on Dynamics with Examples and Experimental Work. By TERRY THOMAS, M.A., B.Sc., LL.B. London: Crosby, Lockwood and Son. [Price 6*s.* net.]

The Ownership and Valuation of Mineral Property in the United Kingdom. By Sir R. A. S. REDMAYNE, K.C.B., and GILBERT STONE. London: Longmans, Green and Co. [Price 12*s.* 6*d.* net.]

Distribution by Steel (Gas and Water) with High-Pressure Tables for Flow of Gas in Mains. By HENRY WOODALL, M.Inst.C.E., and B. R. PARKINSON, M.I.Mech.E. Second edition. London: Benn Brothers, Limited. [Price 15*s.* net.]

Aircraft and Automobile Materials of Construction. Vol. I. *Ferrous Materials.* By ARTHUR W. JUDGE. London: Sir Isaac Pitman and Sons, Limited. [Price 25*s.* net.]

Repairs to Boilers and Engines by Welding. Manchester: The National Boiler and General Insurance Company, Limited. [Price 1*s.*]

Acquisition of Land. What has been Done to Cheapen and Expedite the Acquisition of Land by Public Authorities—and some Fallacies. London: The Land Union. [Price 1*s.*]

Die Heizgase der Technik. VON HANS VON JÜPTNER. Leipzig: Arthur Felix. [Price 16 marks.]

Hydraulic Machinery: Its Design and Maintenance. Chester: Hydraulic Engineering Company, Limited. [Price 5*s.*]

Textbook of Applied Aeronautic Engineering. By HENRY WOODHOUSE. New York: The Century Company; London: T. Werner Laurie, Limited. [Price 42*s.* net.]

Canada, Department of Mines, Mines Branch. Preliminary Report of the Mineral Production of Canada, during the Calendar Year, 1919. Prepared by JOHN MCLEISH, B.A. Bulletin No. 31. *Report on Some Sources of Helium in the British Empire.* By J. C. MCLENNAN, Ph.D., F.R.S. Ottawa: J. de Labroquerie Taché.

An Introduction to Chemical Engineering. An Elementary Textbook for the Use of Students and Users of Chemical Machinery. By A. F. ALLEN, B.Sc., F.C.S., LL.B. London: Sir Isaac Pitman and Sons, Limited. [Price 10*s.* 6*d.* net.]

AERONAUTICAL EXHIBITION AT PARIS.—The seventh International Aeronautical Exhibition will be in December. It is being organised by the Commissariat General de l'Exposition Internationale de Locomotion, 9, Rue Anatale de la Force, Paris, 17.

THE LATE MR. JOSEPH ADAMSON.

WE regret to have to announce the death, which occurred on Saturday last, the 14th inst., of Mr. Joseph Adamson, the founder of the firm of Joseph Adamson and Co., engineers, Hyde, near Manchester. Mr. Adamson was born in 1843, and after having been educated by private tuition, in 1858 he was apprenticed under his uncle, the late Mr. Daniel Adamson, in the firm of Daniel Adamson and Co. In 1863 he was made shop foreman. In 1865 he had charge of the drawing office and the works, remaining with the firm till 1873 in sole charge, till he left to start business on his own account. Mr. Adamson was, of course, associated with the adoption of steel for boiler work in place of iron, the then new material having been adopted by the firm of Messrs. Daniel Adamson in 1858, although the cost of steel was then comparatively high. In 1874 the present firm was started by Mr. Joseph Adamson in partnership with Mr. Henry Booth, who retired from it in 1887. The works adjoin Hyde station, on the railways to Manchester, with which they are directly connected by a private siding, and under Mr. Adamson's personal supervision they have acquired an excellent reputation in the manufacture of high-class steam boilers, electric cranes, plate work of all kinds, sugar, soap-making and other machinery. Mr. Adamson was elected a member of the Institution of Mechanical Engineers in 1871, and was since 1890 a member of the Iron and Steel Institute; he was also an original member of the Institute of Metals and past-president of the Manchester Association of Engineers.

PUMPS FOR CORROSIVE LIQUIDS.

THE development of the chemical industry continually makes demands upon the engineer for apparatus of a special kind which, furthermore, is required to operate under conditions which call for properties entirely outside the ordinary characteristics of mechanical equipment. Strongly corrosive liquids have to be pumped and stored, often at a high temperature and considerable pressure, and not only must this be done with complete safety to the operators, but the apparatus must be neither dissolved, corroded or eroded in the process. Should the pumps, piping or vats, &c., be attacked by the substance in contact with them, their rapid destruction might be the least of the trouble. Any such attack would necessarily contaminate the chemicals with the dissolved material, and might easily be serious enough from this point alone to render the process impracticable.

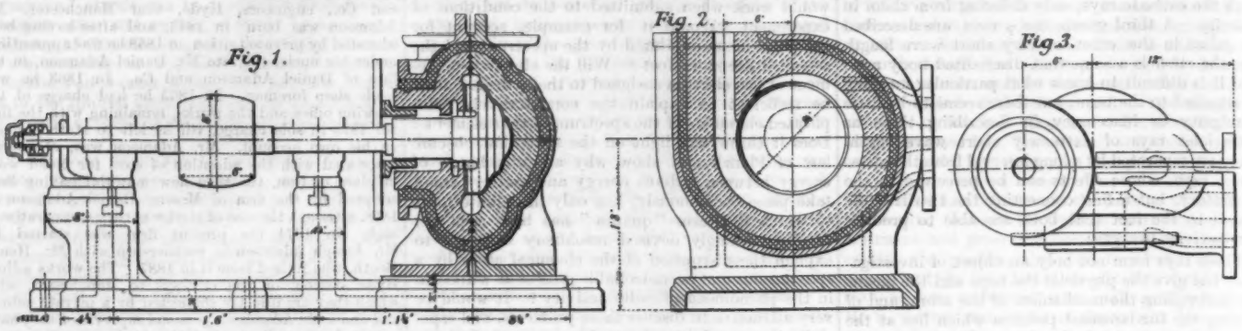
When the conditions are very severe, pumps of the reciprocal type are out of the question, as the centrifugal pump with its natural simplicity of construction, its absence of internal rubbing surfaces and its freedom from valves possesses obvious advantages. Centrifugal pumps, therefore, are widely used for pumping corrosive liquids, and they are made of various materials. Ferro-silicon will resist some acids, but cannot be used for hydrochloric acid or in processes where contamination with iron must be avoided. Lead and regulus metal are also used for pumps but are unsuitable for some acids and for solutions containing metallic salts. Ebonite pumps have been built, but these naturally will not withstand hot liquids, while certain chemicals will attack them. Moreover, ebonite is a bad material for the rubbing surfaces of the glands.

The substance which is most generally suitable for resisting the action of corrosive liquids is some kind of silicious ceramic material, as this can be obtained in forms which are quite insoluble in almost any liquid. Ceramic material is also of a very hard nature, so that it is practically unaffected by erosion. Hence, in spite of its intractable disposition and somewhat unsatisfactory mechanical properties, it has been brought into use for many purposes. A new acid-ware, called ceratherm, was prepared during the war under the necessity of finding some substance suitable for apparatus for the condensation of large quantities of acid gas. Like silica-ware, it can be plunged when red hot into cold water without cracking, and its good heat conductivity permits of a rapid equalisation of temperature in vessels of which it is made.

A modified form of ceratherm, having a higher tensile strength, and possessing the further advantage of being more easily manufactured to accurate dimensions, has been adopted by Messrs. Guthrie and Co., of Accrington, in the manufacture of their acid-proof pumps and other articles. The material is entirely unaffected by almost every chemical solution and may be brought into contact suddenly with either hot or cold liquid without any danger of cracking. The use of this material has enabled Messrs. Guthrie and Co. to put on the market a line of pumps which mark a distinct advance in design and construction over the German made apparatus which was used in this country before the war. The general nature of the ceratherm acid-proof pump will be understood from Figs. 1 to 6, on page 254. The acid-proof material, forming the body of the pump is very thick and strong

CERATHERM PUMPS FOR CORROSIVE LIQUIDS.

CONSTRUCTED BY MESSRS. GUTHRIE AND CO., ENGINEERS, ACCRINGTON.



and is cemented into an iron casing. It is so arranged that it is only subjected by the bolts to crushing stress. The gland through which the spindle passes is usually on the suction side, so that it is relieved from pressure and the stuffing-box is packed with a small quantity of wool, usually soaked in paraffin wax. Various types of impeller are used, according to the duty required, Figs. 5 and 6 show open and closed types in position in the half-casing of the pump. In Fig. 5, the gland is on the pressure side. In all cases the impeller shaft is continued right through the gland and the internal metal spindle is screwed into a cementing material which fills the interior of the shaft and is also held by screw threads formed in the latter. When the impeller is mounted it is ground and balanced on its own spindle. The thrust of the impeller when working is taken up by a ball-bearing at the end of the spindle far removed from any danger from acid.

The requirements of the chemical industry usually call for a pump designed for lifting comparatively small quantities, say, from 20 gallons to 100 gallons per minute, against a head of anything up to 120 ft. Comparatively high efficiencies are claimed for these little pumps, although when the total power absorbed is so small the question of efficiency would not seem a serious matter. Ceratherm pumps have been built for a head of 300 ft., which corresponds to a pressure of 130 lb. per square inch in the pump casing. Four-inch pumps are constructed to deliver 400 gallons per minute at a head of 90 ft. when running at 1,000 r.p.m. The range of sizes built by Messrs. Guthrie and Co. runs from deliveries from 10 gallons to 5,000 gallons per minute, and comparatively slow rotational speeds are adopted, so that the usual factor of safety of the impellers is about 15 at the normal speed of the pump. They have been used successfully for some years on a commercial scale for pumping sodium peroxide, both hot and cold solutions, a substance which is very troublesome to pump and for which a metallic pump would be useless as the slightest particle of metal passing into the process would do considerable damage. Other awkward liquids such as hydrochloric, nitric and acetic acids, both hot and cold, are also being handled successfully by pumps of this type, and, in fact, the makers claim that they have not yet found any liquid which the ceratherm pump will not deal with successfully.

In addition to the use of ceratherm for the construction of pumps Messrs. Guthrie and Co. employ the same material for valves and for the linings of acid eggs and large vats, &c., as its smooth surface and indestructible qualities make it valuable for many chemical purposes. The firm also specialise in chemical engineering plant of other kinds and manufacture large grinding pans, mixers, hot-drying plates, &c., so that the British chemical industries can now be equipped with the most modern kinds of plant without the necessity of recourse to Continental makers.

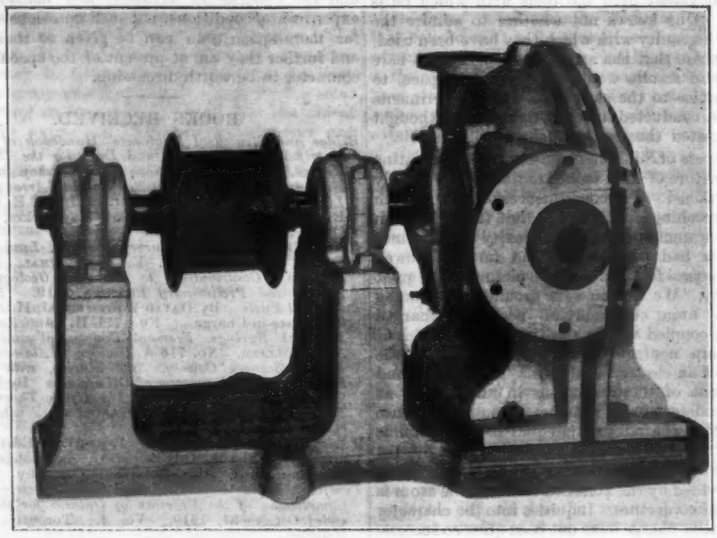
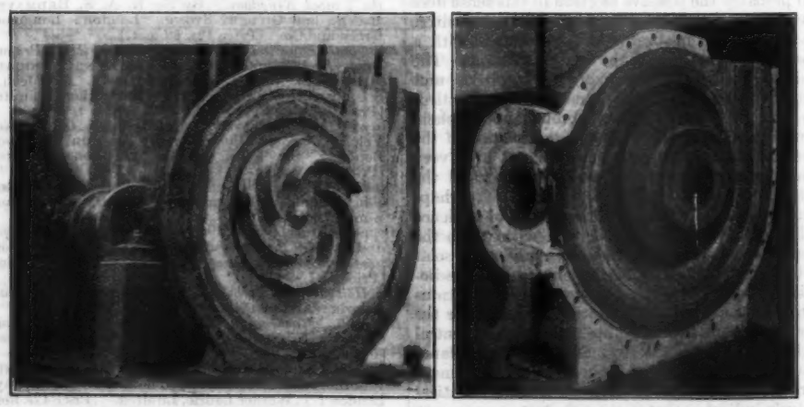


Fig. 4.



Figs. 5 and 6. Interior Views of Ceratherm Pumps.

University of Bristol.—The Faculty of Engineering at this University is provided and maintained by the Society of Merchant Venturers in the Merchant Venturers' Technical College, Bristol. Courses of study are available at the college for persons intended to engage in civil, mechanical, electrical or automobile engineering, and particulars of these courses are given in a prospectus recently issued. The ordinances and regulations relating to degrees and certificates in engineering subjects are included, and some particulars of the Bristol Sandwich system of training engineers are also given. The prospectus can be obtained from the Registrar of the University, Tyndall's Park, Bristol. Messrs. W. H. Dorman and Co., Limited, Stafford, have presented to the Automobile Engineering Department of the Technical College a standard 10 h.p. petrol engine, complete with all details, to be used in investigations on the use of fuels and for trials of various types of carburettors, &c.

The Spanish Navy.—We read in *Moniteur de la Flotte* that as soon as the present Spanish naval programme is completed, a new one will be taken in hand. This is to comprise three battleships of 20,000 tons to 25,000 tons, several light cruisers, mail ships (*navires postaux*) which can be easily armed, 100 destroyers of 900 tons to 1,000 tons, 7 conveying ships of 2,000 tons, 50 submarines of at least 600 tons, some of which to be used for mine-laying, and seaplanes.

Paris School of Political Sciences.—We have received from this school, the name of which is Ecole libre des Sciences politiques, a pamphlet in English which gives particulars of the studies it deals with. The courses are divided into five sections—I. Administrative Section, II. Economical and Financial Section; III. Economical and Social Section; IV. Diplomatic Section; V. General Section (Public Law and History). In each section there are regular courses and optional courses. The students are admitted to the lectures without examination, and no diploma is required as a qualification. The annual fee conferring the right to attend courses and conferences, and to use the library, is £20; one half-yearly fee is £12. The next session commences on November 8, and ends on June 4, 1921, divided into two terms, the second commencing on March 1, 1921. A booklet containing all necessary information as to programme, examinations, &c., can be obtained from the Secretary of the Ecole libre des Sciences politiques, 27, Rue St. Guillaume, Paris, vi.

800-TON ELECTRIC SLIPWAY MACHINERY AT SOUTHAMPTON.

CONSTRUCTED BY MESSRS. DAY AND SUMMERS, LIMITED, ENGINEERS, SOUTHAMPTON.

Fig. 5.

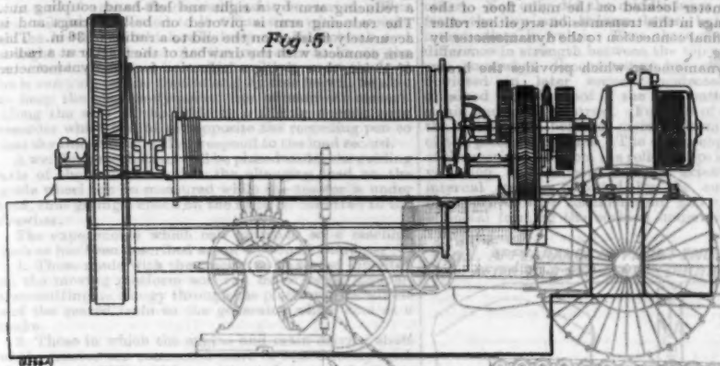


Fig. 6.

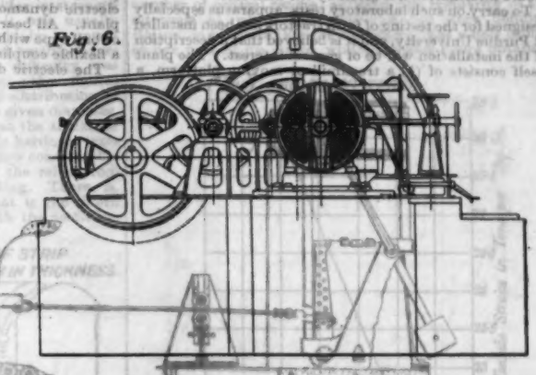
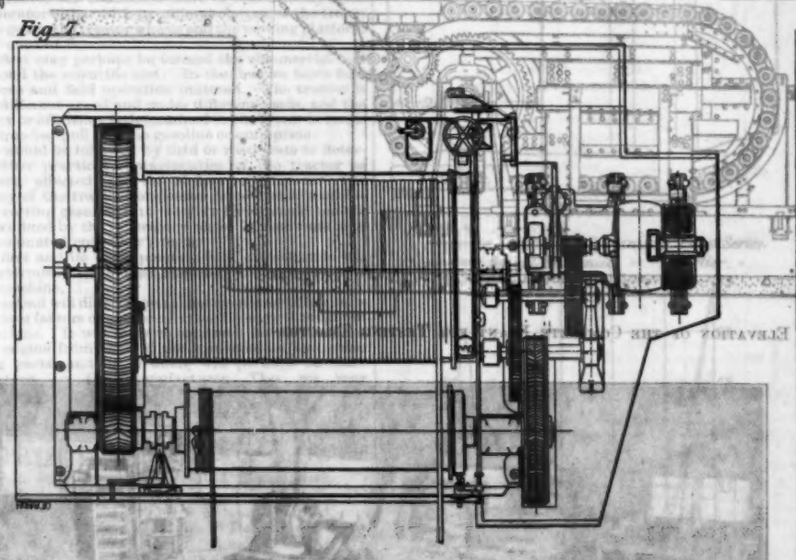


Fig. 7.



The use of slipway haulage machinery for raising vessels out of the water was first introduced in 1879 by Messrs. Day, Summers and Co., Limited, of Southampton, who obtained a patent for the invention and built the first set of such machinery for use in their own yard. This original haulage gear is still in good order and is in constant use dealing with vessels up to the largest size for which it was designed, although a few years ago it was considered advisable to replace the wire rope by a new one. The original rope, 10 in. in circumference, supplied by Messrs. Bullivant and Co., was in use for no less than thirty-two years, during which period it hauled up 720 vessels aggregating about 332,000 tons. It was discarded on account of surface wear, but subsequent tests showed that it might have been safely employed for several years longer.

Since this first installation, Messrs. Day, Summers and Co., Limited, have built slipway haulage gears for all parts of the world, arranged for driving by steam engines, by crude oil engines or electric motors according as local circumstances indicated. The development of this branch of their work caused the firm to standardise their haulage gears, and as a consequence they now build machinery of this kind in nine standard sizes capable of dealing with vessels ranging from 100 tons to 3,500 tons deadweight. Either single-barrel or double-barrel haulage is provided according to the requirements of the case or the space available for machinery. Where there are two slipways side by side, the same set of machinery can be used for both, provided that a sufficiently long lead of rope can be obtained. Otherwise the two sets of machinery which are necessary can both be driven by a single engine or motor.

Figs. 1 to 4, on page 246, show a 2,000-ton haulage gear with double barrels constructed during the war for the Ayrshire Dockyard Company, of Irvine. Each main barrel is driven by its own reversible motor, and the two sets are coupled together when desired by means of clutches on the fourth motion shaft, so that the speeds of the winding barrels are positively equalised. Each motor is operated by its own controller, the controller handles being mechanically coupled when both motors are used together. The hauling up of the cradle is done with two parts of rope leading from drum X, Fig. 2, round a sheave at the centre of the cradle and thence to drum Y. Shunt regulation of the motors permits of faster speeds being used when smaller vessels are being hauled up. When vessels are being launched, the main ropes are coupled up and are paid out from the main drums exactly at the same speed as the hauling down rope is wound on to the other drums. To prevent any undue strain on the ropes the hauling down barrels are driven by means of friction clutches operated from the control platform.

In the event of either motor being disabled, the slip can be used for hauling vessels up to 1,000 tons with one motor only. The main barrels are fitted with holdfast gear for this purpose. Supposing, for example, that the motor marked X in Fig. 2 gave out when hoisting, the drum X would have the holdfast gear applied, and the motor Y would proceed with the hauling on drum Y. When this latter drum is filled, it is held in turn by the holdfast gear, and the motor Y is then used to drive the drum X through the connecting shaft until the vessel is at the top of the ways. The 2,000-ton slipway, in question, was constructed with cast-iron rails on concrete foundations. The work involved the building of two permanent jetties, one on each side of the slip, and the construction of a cofferdam outside.

Figs. 5, 6 and 7 represent the machinery built by Messrs. Day, Summers and Co., Limited, last year, for operating a slipway at the yard of Messrs. Camper and Nicholson, Limited, of Southampton. This is of the single-drum design, driven by a reversible continuous-current motor. The cradle which travels up and down the slipway is made in four positions coupled together, each portion having an independent sheaf block.

This arrangement not only permits a length of cradle to be used to suit the length of the ship to be hauled up, but gives the additional advantage that a vessel can be hauled up, painted and relaunched by means of the lower portion of the cradle whilst another vessel is undergoing extensive repairs on the upper portion.

With the cradle in question, the winch is designed to haul up vessels of 800 tons, using three parts of rope and the whole length of the cradle. By using only two parts of rope a vessel of 550 tons deadweight may be hauled up at a correspondingly greater speed. With vessels of 250 tons deadweight only one part of rope is used.

A vessel of 800 tons can be launched with one part of rope only at a very fast speed, the empty cradle can be hauled up quickly, the blocks set for another vessel and the cradle relaunched with ropes arranged as required, all in time for the next tide. This quickness of manipulation effects a very great saving in slipway costs.

As the inclination of the groundways in Messrs. Camper and Nicholson's yard was not sufficient to enable the cradle to launch itself by its own weight, a small hauling down barrel was fitted in front of the main barrel as shown in the illustrations. This hauling-down barrel is in fact always fitted with Messrs. Day and Summers' standard slipway machinery. The haul-down rope passes from the barrel round a sheave fixed at the lower end of the slipway, and is led thence to the cradle. The small barrel is arranged for independent driving and is fitted with a powerful brake so that it can be used for general haulage about the slipway or other purposes of the shipyard. The large barrel is grooved, and will take the entire length of the hauling up cable without fleeting.

A vessel can be launched without using the motor by declutching the latter and letting the descending vessel pull the drum round against the control of a powerful brake. The faster running gear wheels are all machine cut, and the slower double-helical wheels are machine moulded. The motor is fitted with a solenoid brake for holding the gear when immobility is desired.

The rails of the 800-ton slipway are of steel with cast-iron pawl track laid upon timber longitudinals, the entire foundations being of timber resting on wooden piles. The piles below low water-level were cut by divers under water, the timber structure being erected on shore, launched to site and sunk in place with rails and pawl track fitted.

The cradles of both the slipways are of steel, and are fitted with wheels and carriages of strong design, all of which are interchangeable as regards the side and centre ways. The wheel spindles run in top half brasses of gun-metal let into closed eyebrackets, and provided with grease lubrication, a design which has proved effective in avoiding trouble due to the accumulation of mud in the bearings.

THE TESTING OF FARM TRACTORS.*

By Charles H. Benjamin,† Lafayette, Ind.

The latest machine to claim the attention of the investigator is the farm tractor. Its development has naturally followed that of the automobile and the motor truck, and the farmer, comparatively isolated as he is, finds the use of individual motive power almost a necessity. But, like all newly-invented machines, the farm tractor is imperfect, and will not always do the work expected of it. Field tests throw some light on its

* Paper presented at the Mid-West Sections Meeting, Indianapolis, Ind., October 24 and 25, 1919, of the American Society of Mechanical Engineers.

† Dean, Purdue University, Lafayette, Ind., Mem. Am. Soc. M.E.

good and bad points, but unfortunately they do not always locate the source of poor performance. A laboratory test, on the other hand, if it fairly imitates what we may call standard working conditions, will enable us to compare one machine with another and thus secure information not given by the field test.

To carry on such laboratory tests, apparatus especially designed for the testing of farm tractors has been installed at Purdue University, and it is believed that a description of the installation will be of general interest. The plant itself consists of (1) a treadmill or moving platform, a sort of inverted "caterpillar" supported on driving wheels and idle rollers, and in its turn supporting the driving wheels or lugs of the tractor; (2) a traction dynamometer to receive and measure the pull of the tractor; (3) an absorption dynamometer to control and measure the energy transmitted through the treadmill and its supporting wheels.

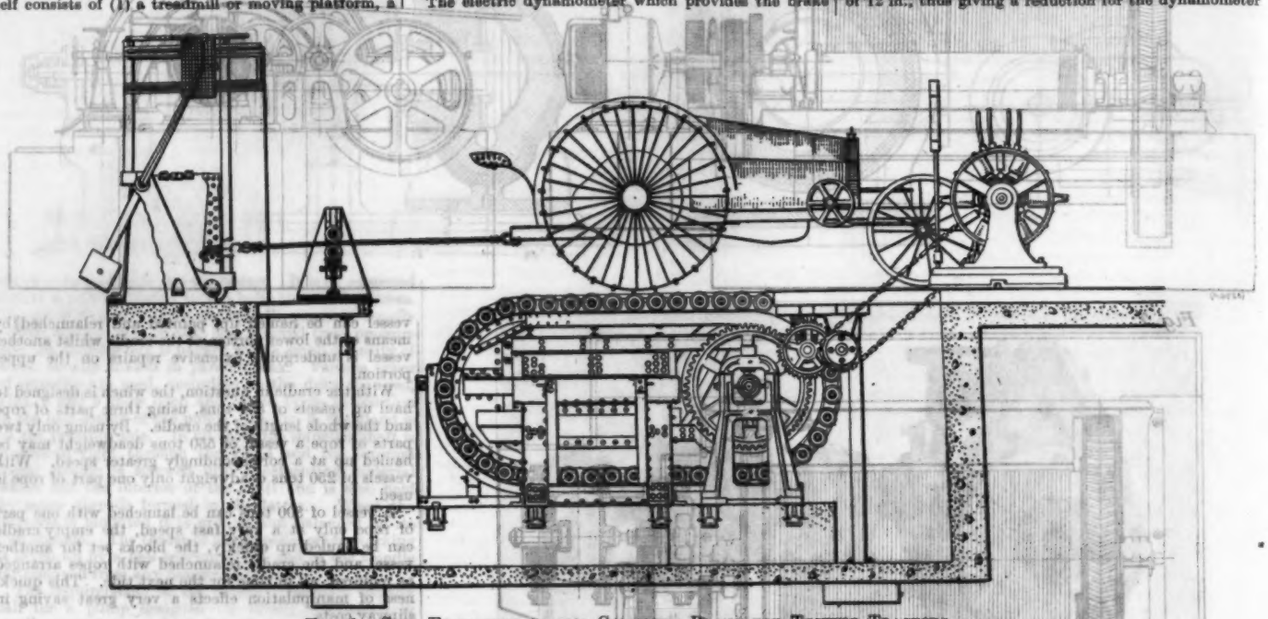


FIG. 1. SIDE ELEVATION OF THE COMPLETE PLANT FOR TESTING TRACTORS.

The plant, which is a permanent equipment for the engineering experiment station, is capable of testing tractors weighing as high as 12,000 lb. on the driving wheels and giving a drawbar pull of about 5,000 lb. at a speed not to exceed 5 m.p.h.; these tractors being either single or double-wheel, front or rear drive, or of the caterpillar type, with maximum tread for the double-wheel tractor of 84 in. and a caterpillar length of 96 in., the face of the drivers not being greater than 26 in.

The plant is of the treadmill type having two caterpillar treads of 26 in. width, carried on a structural-steel frame so designed that with little difficulty it can be changed to accommodate the various styles of tractors.

The steelwork consists in part of a main frame made up of three 8-in. I-beams running across the plant resting on permanent supports at each end and on a movable support in the centre, all supports being bolted to the foundation.

On the main frame are two rectangular frames which can be moved along the 8-in. I-beams, thus taking care of the different treads of the tractors, or one can be placed in the centre to accommodate the single-wheel type. The top of each rectangular frame is made up of four 3-in. I-beams for cross-members, which support the caterpillar tracks. These 3-in. beams can be removed and replaced by a weighing mechanism, so that the weight of the tractor on the driving wheels can be obtained while in operation.

At the rear end of each rectangular frame is a sliding semi-circular track which transfers the caterpillar tread from the top to the bottom track, these tracks being forced endways by means of compression springs which maintain the desired tension on the caterpillar tread.

Under the rectangular frame is a separate track bolted to the foundation for the purpose of carrying the weight of the caterpillar tread on the return. Fig. 1 shows a side elevation of the complete plant.

The caterpillar tread consists of ninety-four 7-in. cast steel links, 26 in. wide, each link being carried on four 5-in. wheels equipped with bronze bearings. These wheels provide support for the links at all times except as they come around 48-in. pulleys at the front end, when the under sides of the links, which are curved to fit, transmit the pull to the 48-in. pulleys. To the upper sides of the links are bolted hard maple blocks, 26 in. long, 6 in. wide and 4½ in. thick, leaving 1 in. between the blocks. Lugs can be provided on the tractor driver wheels to mesh in the gaps and thus prevent slippage between caterpillar and wheel. Fig. 2 is a general view of the plant.

The 48-in. pulleys which take the pull from the caterpillar tread have glued and riveted to their faces strips of conveyor belting 26 in. wide and ½ in. thick, to reduce slippage between the links and the pulleys. These pulleys are mounted on a 5-in. shaft, which is carried on three pedestals equipped with roller bearings. Two of the pedestals can be moved along the shaft to take care of the different positions of the pulleys due to the change of tread of the tractors. From the end of this shaft the power is transmitted by gears and silent chain to an electric dynamometer located on the main floor of the plant. All bearings in this transmission are either roller or ball type with final connection to the dynamometer by a flexible coupling.

The electric dynamometer which provides the brake load for the plant is of the Sprague Electric Company's standard design, rated at 100 h.p. at 1,200 r.p.m., and so wired as to operate either as a generator-dynamometer or as a motor dynamometer. When operating as a generator-dynamometer the energy generated is absorbed by air-cooled rheostats, the resistance of which can be varied to accommodate the load. The rotating part of the dynamometer is supported on ball-bearing pedestals and by suitable linkwork connected to standard scales. These scales are so connected that the only readings necessary to determine the horse-power being transmitted are the weight on the scales and the revolutions per minute of the dynamometer.

The drawbar dynamometer is of the pendulum type, the pendulum and the recording arm being carried by a 5-in. drum hung on ball bearings. The pendulum weight and the recording arm are so proportioned that the record made by the recording pen shows 200 lb. drawbar pull for every inch of movement from the vertical position. Tangent to the 5-in. drum, a flexible steel plate 0·025 in. thick is fastened, connecting it with a reducing arm by a right and left-hand coupling nut. The reducing arm is pivoted on ball bearings and is accurately finished on the end to a radius of 36 in. This arm connects with the drawbar of the tractor at a radius of 12 in., thus giving a reduction for the dynamometer weight of three to one. To the 12-in. arm is attached a flat piece of steel 0·045 in. thick which is connected to the ¼-in. wire rope going to the drawbar of the tractor. This rope passes through a four-wheel guide which can be lowered or raised so that the pull on the tractor will be level at all times and so that there will be no chance for side pull on the dynamometer if the tractor should swing off the centre line.

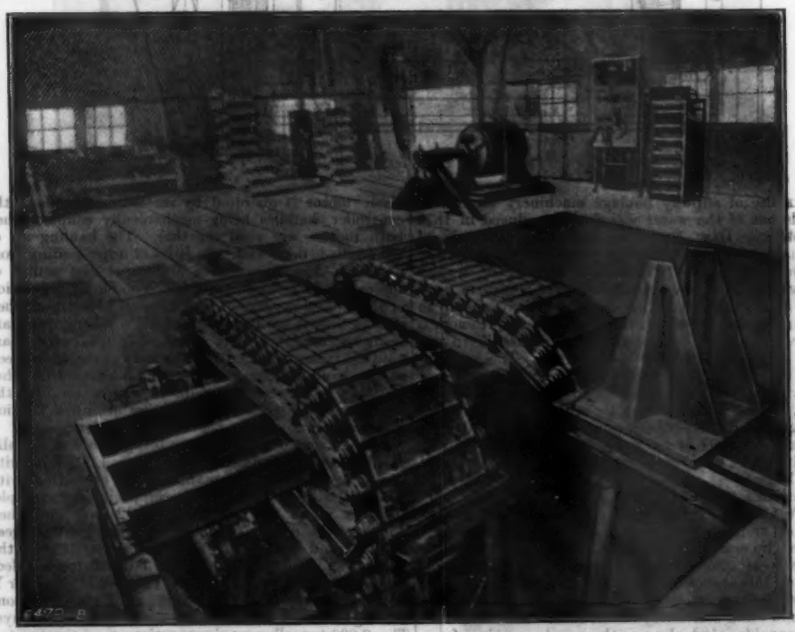


FIG. 2. GENERAL VIEW OF THE PLANT SHOWING THE ELECTRICAL EQUIPMENT.

The recording apparatus for the drawbar dynamometer consists of a vertical brass table which can be moved along suitable guides to take care of the different loads. The 10-in. record paper is carried over the table from the lower roll to the upper, the winding mechanism being driven from the main 5-in. shaft of the plant so that the speed of the paper is in exact proportion to the speed of

the tractor. Above the recording table are two recording arms which can be moved along a graduated scale, one arm with its pen marking the zero line for the test; i.e., if test is run at 2,000 lb. drawbar pull, the zero line would be placed at 1,500 lb. or 1,800 lb., thus giving a card which would be easy to measure. The second recording arm would be set at the desired load to be carried. This arm will have fastened to it a fine wire with a weight at the lower end which will keep the line plumb and straight at all times. As the operator looks at the recorder, he will see a line which will represent the load he is carrying on the tractor and by this he will be able to keep the electric-dynamometer adjustment correct. Along the side of the table is a sliding electric time recorder which can be set opposite the recording pen so that the time record will correspond to the load record.

A weighing mechanism will be placed under the guiding axle of the tractor so that the changing load on the guide wheel can be measured while the tractor is under load, thus giving a check on the force transmitted to the drawbar.

The experiments which can be made on a machine such as has been described are of a twofold character:—

1. Those made with the tractor to be tested mounted on the moving platform and run in its usual manner, transmitting its energy through the platform, the wheels and the geared train to the generator which acts as a brake.

2. Those in which the engine and main driving shaft of the tractor are connected more or less directly with the generator either with or without the use of the transmission gears, the tractor wheels and the moving platform being "cut out."

The first may perhaps be termed the commercial and the second the scientific test. In the first we have field conditions and field operation imitated. The tractor is run at different speed and under different loads, and the economy or efficiency is determined in the gross, in terms of the drawbar pull and the gasoline consumption.

This would be followed by field or road tests to determine other practical characteristics of the tractor as they are affected by out-of-door conditions. The efficiency of the tractor considered merely as a machine for converting gasoline into tractive force would remain as determined by the laboratory tests. These tests may be denominated consumer's tests.

The first and its corresponding field experiments will have determined the overall efficiency of the tractor as a power machine.

The second will differentiate these results and distribute the various factors of efficiency or inefficiency throughout the machine. It will serve to separate the performance of the engine from that of the transmission and other moving parts, and in so doing will perhaps be more satisfactory to the manufacturer. This we may denominate a producer's test.

THE INFLUENCE OF COLD ROLLING ON THE PHYSICAL PROPERTIES OF COPPER.*

By F. JOHNSON, M.Sc., Member, Birmingham.

IN a former Note† presented to the Institute the author dealt with the influence of uninterrupted cold rolling on the properties of copper free from oxygen. It was there shown that a stage occurred during rolling at which there was a tendency for the maximum stress, percentage elongation, and scleroscopic hardness to reach constant values over a certain range of reduction. Alkins‡ had previously shown that in the uninterrupted drawing of copper wire containing cuprous oxide the tensile strength, specific gravity, &c., remained constant over a similar range. On account of the smallness of the sample, it was not possible to carry out an exhaustive series of hardness tests, nor to be quite certain that the tensile stress tests of the very thin specimens were strictly representative. Nor was it possible to examine the internal hardness of the specimens. Owing to the kindness of Mr. J. R. Johnson, of Messrs. Elliots Metal Company, Limited, the author was enabled to procure a sample of wire bar copper which had been hot-rolled to a 2-in. square section billet. The composition of the billet was as follows: Copper, 99·94 per cent.; oxygen, 0·05 per cent. The billet was cut into 10-in. lengths, which were rolled cold into strips 1·5 in. thick by 2·167 in. wide. These strips were then annealed. The temperatures of the gas-fired muffle were taken by means of a platinum-platinum-rhodium thermocouple and an indicator reading in degrees Centigrade. The temperature readings were carefully taken, and the temperature of the pieces, which were all arranged close together on the hearth of the muffle, rose steadily to a maximum of 850 deg. C., which was maintained throughout the rest of the process. The time taken for the pieces to reach the maximum was half an hour, and they remained at that temperature for another half hour. During this period no signs of lack of uniformity of temperature were observable, the whole set appearing to have reached a uniform bright red colour. The pieces were taken from the furnace, quenched in water, pickled in dilute sulphuric acid to remove scale, rinsed and dried, and then rolled cold to thicknesses varying from 1·231 in. down to 0·033 in. It was necessary to change from one set of rolls to another; but the change was not made until a reduction in thickness of 87 per cent. had been effected, so that any possible disturbing influence due to change of diameter and speed of rolls could not come into operation before this stage.

Tensil Tests.—Much difficulty was experienced in the preparation of test-pieces from the strips representing the earlier stages of reduction. It was found that the cutting up of the strips laterally revealed considerable disparity between the strengths of the various zones. It became necessary, therefore, to arrange for the slitting and milling of the strips so as to produce slices representing the full thickness from one rolled face to the other. Not only did the middle layer differ in strength from the top and bottom layer, but it was usually intermediate in value. That there should be so much difference in strength between the top and bottom layers was somewhat disconcerting, but this difficulty was obviated in later series. Incidentally, the figures obtained furnish proof of the differential distribution of strain under rolling stress. For rolls of a given diameter, the distribution becomes more uniform as the thickness of the piece diminishes. The scleroscopic hardness tests of the sections cut from the rolled strips show considerable variation, and indicate to some extent the relief from internal stresses afforded by the cutting. There is, however, another consideration, and that is the depth of metal forming the cushion underneath the test-face.

Fig. 1. APPEARANCE OF FRONT END OF STRIP AFTER 70·8 PER CENT REDUCTION IN THICKNESS.

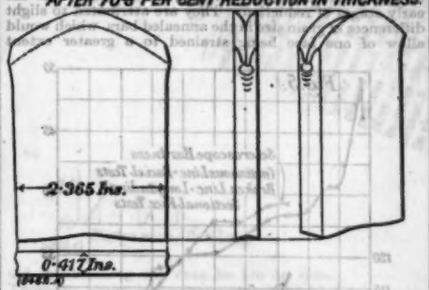
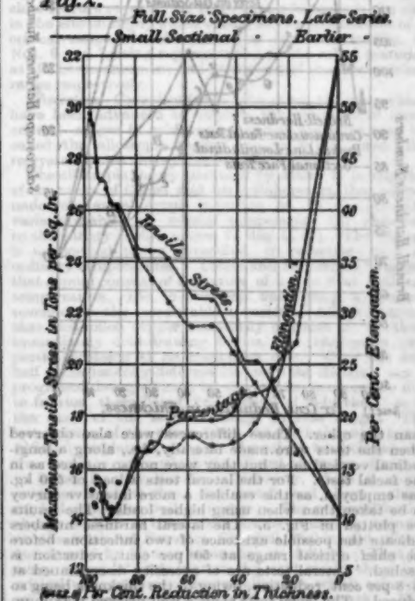
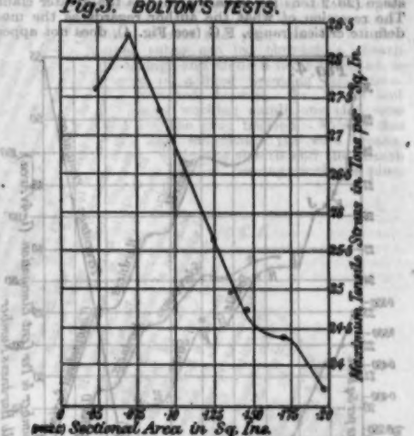


Fig. 2.



When the rolled strip itself is being tested this cushion is considerably deeper than when the sectional test pieces are used, and the cumulative effect of these layers of elastically-stressed material may not be insignificant. With the thinner strips (beyond 80 per cent. reduction) it became more convenient to prepare tensile test pieces whose width was greater than their thickness. The reverse of this arrangement had obtained with the thicker strips. The strips were wide enough to provide three test specimens, and appreciable variations in strength were noted between the centre and outer specimens. This is attributed to differential flow of the metal. There is a lag in the rate of longitudinal flow of metal at the sides of the strips, because this metal is called upon to a greater extent than that at the centre to provide for lateral spread. The greater extension of the metal at the centre is shown in the shape of the strip at the front end; the metal at the centre being in advance of that at the edges (see Fig. 1). It is possible that the combination of transverse and longitudinal stresses on the structural condition of the cuprous oxide may be partly responsible for the lower tensile strength of the metal at the edges. This lower strength is accompanied often, but not always, by lower percentage elongation. The thickness of metal at the centre is always slightly greater than at the sides. In the author's previous Note it was pointed out that there was a suggestion of a second critical range of deformation at 80 per cent. reduction. Owing to insufficiency of material it was not then possible to establish the existence of the suspected critical range, and it was hoped, in the course of the present investigation, to throw more light on the matter. T. Bolton has suggested that "possibly the phenomenon was recurrent at regular intervals, which might be determinable for any given material." By referring to Fig. 2 it will be seen that the curves show a number of critical ranges, although the regularity of the intervals at which they occur is not very definite. Bolton, in his tests (Fig. 3), has shown that a halt occurs at one part of his curve, whilst the last figure obtained

Fig. 3. BOLTON'S TESTS.



represents a falling-off from the maximum at 26·3 tons per square inch. This indication of a reversion to a softer condition is somewhat confirmed by other figures given by Bolton, to the effect that wire which has already been highly wrought so as to possess a tensile strength of 29 tons per square inch at 0·194 in. diameter may, upon further drawing, pass through a critical range between 0·079 in. and 0·048 in. diameter, over which the tensile strength is constant at 33·3 tons per square inch, and the elongation only 1 per cent. Beyond this critical range the tensile strength is increased by further drawing to a maximum of 41·6 tons per square inch, but, strangely enough, this increase of strength is accompanied by an increase in the elongation to 2·1 per cent. The value of the figures obtained on such thin wires as those quoted (0·015 in. diameter) is, perhaps, not so precise as that of the figures obtained on thicker wires, and the extremely high tensile strength of 41·6 tons per square inch appears to have excited no comment from subsequent investigators. It is a remarkable figure, and is in itself suggestive of further research.

Tensile Stress Tests.—From a consideration of the lower curve in Fig. 2 it will be seen that there is a very well-defined critical range between 50 per cent. and 60 per cent. reduction at a value of 21·5 tons per square inch—a somewhat lower value than was obtained in the author's tests on oxygen-free copper (23 tons per square inch). There is the suggestion of another critical range at 75 per cent. reduction, and of another at 87 per cent. reduction. As these results were obtained from tests on cut sections, it was obvious that the tensile strength of the rolled strips had been lowered by cutting, in a similar way to the hardness. The strips were therefore sectioned to provide test pieces whose width represented the full thickness of the strip. As the preparation of these test pieces presented considerable difficulties several months elapsed before testing could be commenced. It was decided to have the whole series of test pieces ready, and to test them all at one time. This was done five months after the rolling of the strips. The upper curve (Fig. 2) shows the results obtained, and affords a very striking confirmation of Bolton's prophetic statement.

Elongation.—The percentage elongation was measured on a gauge length which had a constant ratio to the cross-sectional area. The formula employed was the same as in the previous experiments, viz.:

$$l = 4\sqrt{\text{area}}$$

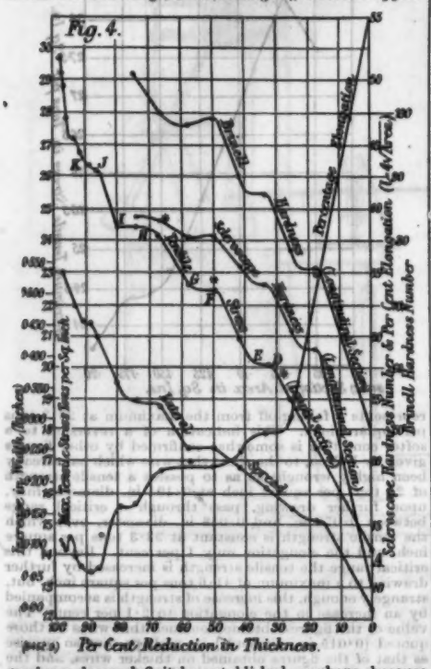
where l = gauge length.

The curve plotted in Fig. 4 shows a very rapid decrease in elongation up to 30 per cent. reduction, followed by a series of ranges over each of which the values are fairly constant, followed again by a rapid fall to a minimum. The application of work beyond the 90 per cent. reduction stage actually results in an increase in percentage elongation. The ranges of constant elongation agree fairly well in position with the ranges of constant tenacity. It may be that the formula employed is not necessarily the best one to use under the circumstances, and on this point the author invites criticism. There is no doubt, however, about the rise in elongation; and it is of interest to note that the point of minimum elongation occurs at about 90 per cent. reduction, at which stage there is a critical point in the curves for scleroscope hardness, tensile strength, and lateral spread. It is at about this point also that the maximum Brinell hardness occurs. It is especially to be noted that the tensile strength and scleroscope hardness continue to increase beyond this point, whereas the percentage elongation commences to increase also. The Brinell hardness shows a rapid decline from this point, and unlike the two first-mentioned properties is a reflection of the rise in elongation. The increasing thinness of the material cannot be urged as a disturbing factor in the cases of the first two

* Abstract of a paper read at the meeting of the Institute of Metals on Friday, March 12, 1920.
† See ENGINEERING, vol. cvii, pages 428 and 454.
‡ See ENGINEERING, vol. cvi, pages 283, 292 and 468.

points on the retrogressive slope of the Brinell hardness curve, as these represent material 0·156 in. and 0·129 in. thick respectively. It will be seen from Fig. 4 that a critical range occurs between 70 per cent. and 80 per cent. reduction, and another in the neighbourhood of 87 per cent. There is the suggestion of yet another at 93 per cent., but this may be ignored for the moment. If any relationship exist between the suspected critical range in the author's earlier paper and one of the above-mentioned, it remains to be determined where the identification lies. If tensile strength be taken as a clue, the 87 per cent. stage (26·2 tons per square inch) has the greater claim. The recession of what the author regards as the most definite critical range, F G (see Fig. 4), does not appear

Fig. 4.



to have been definitely established, perhaps because its exact position was not determined in the earlier paper. It is, however, remarkable that this range coincides exactly with the position of the critical range established by Alkins for drawn wire. The tensile strength over the latter range was 23·2 tons per square inch, whilst the tensile strength over the author's range F G is 22·5 tons per square inch. The difference could be attributed to the higher initial strength of the material used by Alkins and to the difference in method of application of work. The coincidence in the positions of these two ranges is very remarkable, and is not affected at all by the great difference in initial dimensions. The evidence afforded by sclerescope hardness tests, upon which Ellis largely relies, must be accepted with caution because the superficial hardness is not a true indication of the hardness of the whole mass. The metal at the surface appears to be subjected, in the earlier passes, to greater strain than the interior, the strains being relatively greater both laterally and longitudinally. Thus the critical range will be reached by the surface metal at an earlier stage than by the inner core, and surface tests alone will be misleading. If, in the case of low initial thickness, the displacement of the metal at the surface relative to that of the inner core be less than in the case of metal of high initial thickness then Ellis' view is not strengthened. The case of detecting the critical ranges is dependent upon the initial thickness for critical changes which occur in the later stages will be more difficult to determine—owing to the smallness of the specimens—the less the initial thickness. On the other hand the specimens obtained from the earlier passes present difficulties in preparation and are far from being homogeneous. (From an experimental standpoint it would have been advantageous to have commenced with pieces of dissimilar thickness and rolled all down to one common gauge. Testing difficulties would have been greatly minimised.) It would be an advantage if the strip chosen for experiment were of such width that specimens taken at any pass would need only to have the edges trimmed true and thus represent practically the whole width of the rolled piece. On the other hand the strip chosen might be so wide that specimens cut from the centre would be almost immune from the influence of lateral spread. The former method would be less troublesome and would have the treble advantage (*a*) of economy (in metal and labour) (*b*) of elimination of discrepancies due to position of test pieces and (*c*) of diminution of variations due to relief from initial stresses incurred in slitting if such occur. These are pitfalls, the existence of which the author expected, but the magnitude of which exceeded his anticipations. It was essential to have all the rolling done at one time, and as expeditiously as possible in order that the works' routine might not be unduly dislocated. The need for the experimental refinements enumerated was revealed during the course of the investigation when the opportunity for introducing them had gone by. It is felt, however, that the results recorded in this paper are fairly representative of the changes which may be expected to occur in practice.

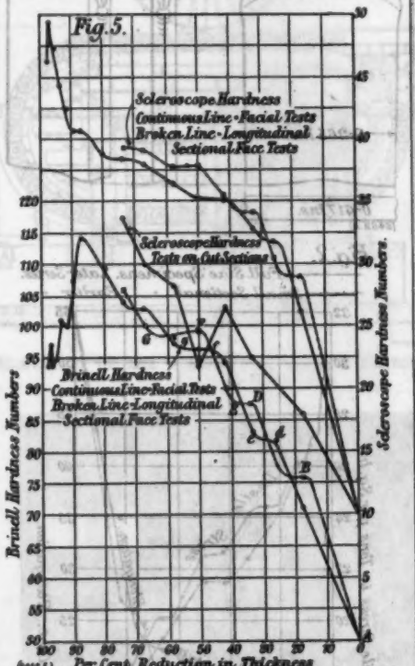
In a paper by W. Müller * dealing with the influence of preparation and rolling on the properties of sheet copper the average values for tensile strength obtained are as follows :—

	Tons per Square Inch.
Before reduction	15·35
After 23·4 per cent. reduction ...	19·79
After 49·8 per cent. reduction ...	22·82
After 65·3 per cent. reduction ...	24·68

These values are indicated as stars on the diagram given in Fig. 4 and it will be seen that they are situated above the author's curve. When it is considered that Müller's figures represent the average of results obtained on material the average initial strength of which was higher than that of the material used by the author the proximity of those figures to the author's curve is remarkable.

Brinell Hardness Tests.—These tests first revealed the differences of hardness between upper and nether faces of the strips and differences were most marked in the early stages of reduction. They are attributed to slight differences of grain size in the annealed bars which would allow of one face being strained to a greater extent

Fig. 5.

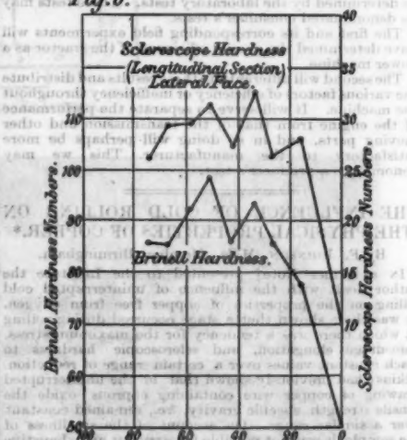

Sclerescope Hardness
Continuous Line - Facial Tests
Broken Line - Longitudinal Sectional Face Tests
Sclerescope Hardness Tests on Cut Sections
Brinell Hardness
Continuous Line-Facial Tests
Broken Line-Longitudinal Sectional Face Tests
Brinell Hardness Numbers.
Sclerescope Hardness Numbers.
Per Cent Reduction in Thickness.

than the other. These differences were also observed when the tests were made laterally, i.e., along a longitudinal vertical face, but they were not so marked as in the facial tests. For the lateral tests a load of 500 kg. was employed, as this enabled a more intensive survey to be taken than when using higher loads. The results are plotted in Fig. 5. The lateral hardness numbers indicate the possible existence of two inflections before the chief critical range at 50 per cent. reduction is reached. Lateral tests are of necessity discontinued at 74·8 per cent. reduction, owing to the thickness being so reduced. The facial tests show a well-marked maximum of 87 per cent. reduction. The inflections indicated by the lateral tests are confirmed by the facial tests, with the exception of the range marked A B. The corresponding ranges in the facial test curve are lettered similarly to those in the lateral test curve, but using small letters. It will be noticed that they occur at earlier stages of reduction. Reference has already been made to the peculiarity that the Brinell hardness tests should show such a marked permanent breakdown at 87 per cent., whereas the sclerescope tests show only a temporary arrest preparatory to a much more rapid rate of increase than before (see Fig. 5). Comparison with the Brinell hardness curve given in the author's previous Note will show a striking quantitative similarity, the greater number of observations in the later series having revealed critical ranges which escaped detection in the earlier exploratory series.

Sclerescope Tests.—The magnifier hammer was used for all the tests, instrument and hammer being both new. The facial tests indicate the existence of four critical ranges, the first two of which, as in the Brinell tests, occur at earlier stages than the corresponding ranges revealed by the lateral tests. The author has already given the probable explanation of this. The critical ranges revealed by the lateral tests coincide in position with those found by the tensile, Brinell, and lateral-spread tests. A very striking feature of these tests is the deceleration in rate of increase of hardness which occurs beyond the 20 per cent. reduction stage. Taking the curve of facial tests the total rise is 21·7 on the sclerescope scale, the rate of increase up to 25 per cent. reduction being approximately 0·87 of a sclerescope unit per unit per cent. reduction in thickness. From 25 per cent. to 90 per cent. the total rise is 8·5 on the sclerescope scale, thus averaging only 0·13 of a sclerescope unit per unit per cent. reduction. Over the next 5 per cent. reduction range (from 90 per cent. to 95 per cent.) the total rise is approximately 9 units, thus averaging 1·8 sclerescope units per unit per cent. reduction. Thus there is a wide intermediate range between 25 per cent. and 90 per cent. reduction over which the average rate of increase of hardness is very low compared with the rates obtaining before and after that range. The subsequent rate of increase is double the prior rate of increase. It has already been pointed out that the Brinell hardness tests indicated a steep decline from the maximum at 87·5 per cent. reduction. The maximum in the sclerescope tests is reached at a later stage, viz. 95·5 per cent., being followed by a similarly steep decline. In the author's former Note the sclerescope tests showed that a maximum was reached at 80 per cent. and remained constant up to 90 per cent., at which point a decline set in. The hardness-reduction curve given in the previous Note and that herein presented are strikingly dissimilar from a quantitative standpoint. There are, however, several features in common—viz., the initial rapid rate of increase followed by a range in which the rate of increase is comparatively low, followed again by a range in which the rate of increase is greater than that of the initial range. In the present case the intermediate range is wider and the rate of increase more sluggish, the converse being true of the initial and final ranges. The maxima in both curves have the same value. Although in one or two isolated cases a value of 50 or slightly over was obtained, the average of a series was always just under 50 in the hardest strips.

It should be pointed out that the two series which have been compared differed from one another in important respects, viz. : (1) Initial thickness, (2) grain size, (3) oxygen content. The curves plotted in Fig. 6 show

Fig. 6.



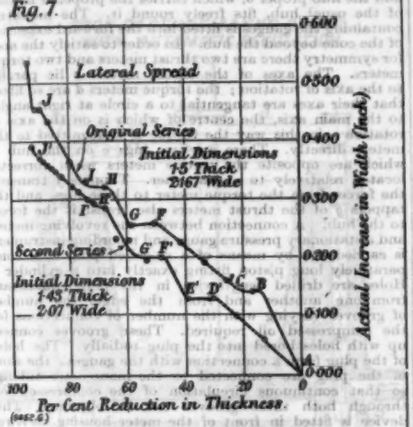
the changes in hardness occurring after slitting the strips. The important feature of these curves is that each peak corresponds with the commencing point of a critical range on the tenacity-reduction curve.

Lateral Spread.—It was thought that there might be some connection between increase in width (lateral spread) and the critical ranges of deformation, although in the process of cold drawing, where lateral spread cannot occur, the existence of at least one critical range has been established. The determination of lateral spread is not simple, because (1) it is not uniform along the rolled strip and (2) the metal at the surface, in contact with the rolls, spreads laterally to a greater extent than the metal at the centre. Thus the section of the strip after rolling shows concave sides (this is not the result which would be obtained with all metals and alloys, under all conditions), and width measurements are therefore accurately determinable only by elaborately measuring the cross-sectional area. The measurements of the author for the rolled strips were obtained by the use of vernier calipers, and the concavity at the sides was ignored. Readings were taken to $\frac{1}{1000}$ in., this degree of accuracy being perhaps greater than the experimental variations warrant. It is considered, however, that, as the measurements were all made in the same way, any marked change in rate of lateral spreading would be susceptible of detection, and would have at least some qualitative significance. The figures are plotted in Fig. 4. It will be seen that there is striking coincidence between the critical ranges of deformation and ranges of constant width in spite of the difficulties of accurate measurement. With one exception viz. the critical range D E in the tenacity-reduction curve all the others are reflected in the lateral-spread-reduction curve which even reflects the B C range of the hardness curves. It was decided to make a confirmatory series of measurements and for this purpose one of the annealed bars was taken and planed so as to have an accurately uniform cross-section. The rolling was designed so as to effect

* Forschungsarbeiten auf dem Gebiete des Ingenieurvereins.

a reduction of approximately 10 per cent. at each pass. Beyond 50 per cent. reduction the passes were more frequent. The strip entered the rolls (16 in. diameter, running at 12 r.p.m.) always in the same direction and always with the same face uppermost. The width measurements varied from front to back and therefore attention was concentrated on the measurements at the middle of the strip. These are plotted in Fig. 7 alongside the curve of the main series. It will be seen from a comparison of these two curves that with a smaller initial thickness. (1·43 in. as compared with 1·5 in.) the lateral spread is less in amount for a given range of reduction in spite of the use of larger diameter rolls at some stages. There are several ranges of constant width, and these correspond fairly well in position with those of the curve from the original series. Strangely enough, the D E range, which does not occur on the original curve, does occur on the second series curve, whilst the B C range does not appear on the latter. The rate of increase in lateral spread appears to be lowered by increasing the number of pinches over a given range. It will be noticed that the critical range H I of the upper

Fig. 7.



curve is much less pronounced on the lower curve, possibly on account of the slower rate of reduction. But another interesting point is that the first portion A B of the upper curve is approximately parallel with the later portion I J, whilst the first portion D'E' of the lower curve is approximately parallel with the later portion I'J', in spite of the difference in the severity of the pinches.

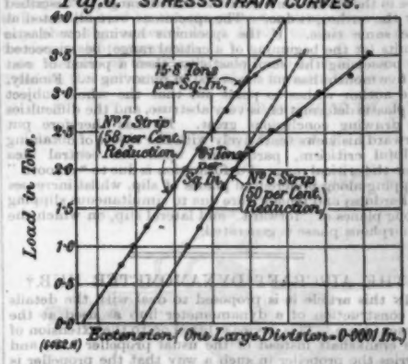
Specific Gravity.—A specimen representing each pass was sawn off and its specific gravity determined, using a hair as a suspending thread. Correlation of the results with the other test results is difficult. There is doubtless a certain lack of homogeneity caused by the haphazard distribution of cuprous oxide and occluded gases, and this may affect the comparability of the results. There may also be a variable influence—especially with the thicker specimens—introduced by the relief from initial stresses afforded by cutting the specimens. The two chief features of the specific gravity determinations previously described in the author's former Note were (1) A rise to a maximum coinciding with the inception of the critical range; (2) a progressive fall from the maximum down to a minimum, followed by a sharp rise to a second low maximum, which coincided with the position of a suspected second critical range.

These results were admittedly obtained under imperfect experimental conditions, but their significance cannot be ignored. There were two peaks in the specific gravity deformation curve, one coinciding with the position of an established critical range and the other with the position of a suspected critical range. An examination of the curve, obtained by plotting the values of the present series, shows that, with the exception of the first critical range at 20 per cent. reduction (the existence of which is not confirmed in the tensile tests), each of the other critical ranges coincides with a peak in the specific gravity curve, and that the curve of the present series commences with a fall in specific gravity, and is followed by a rise.

Microstructure.—A series of photomicrographs was taken of the structure of the strips as revealed by polishing and etching a vertical longitudinal face. Such a section will reveal the influence of cold work at an earlier stage than a horizontal or transverse face, and will show more graphically the progress of the rolling action in the reduction in thickness of the grains as well as in their elongation. The grains of a horizontal section will show elongation, accompanied by slight lateral spread, so that no lamination effect will be shown. In the vertical section evidence of cold work is revealed after the first pass (18 per cent. reduction). The copper-cuprous-oxide eutectic of the original wire-bar had already been broken up and elongated by the hot rolling which the billet had received and shows progressive elongation with cold rolling. The annealed bar had a smaller grain size than that of the hot-forged plate employed in the author's former experiments, and the indications of intra-crystalline deformation were therefore less easy to observe. The most convenient method of etching was to immerse the specimen in a 20 per cent. solution of ammonium persulphate in water for 3 minutes or 4 minutes. This is rather deep etching, but the grain boundaries were revealed better than by light etching. No system of polish attack was employed when it was desired to preserve the etching contrasts of the various grains. For revealing the presence and distribution of cuprous oxide the specimens were lightly rubbed on moist parchment, fed with calcined magnesia and very dilute ammonia. The etching by simple immersion in ammonium persulphate solution produces etching contrasts even in annealed metal.

Elastic Limits.—These were determined by means of a Cambridge extensometer on the larger specimens of the later series only. Two typical stress-strain curves are shown in Fig. 8. The author suggests that a considerable amount of light is to be thrown on the phenomena relating to the influence of cold work on metals by a study of the elastic limits. He regrets the incompleteness of the data given, but suggests that they afford a clue to the structural behaviour of metals subjected to deformation. For

Fig. 8. STRESS-STRAIN CURVES.



aid in obtaining the data he has to thank Mr. J. M. Thomson, senior lecturer in engineering at the Birmingham Technical School, who gave invaluable help. The chief feature revealed by these determinations is the rise in the elastic limit, which occurs at the termination of a critical range of deformation, as is shown in Fig. 8, Nos. 6 and 7, being representative of the rolled material at the commencement and at the end of the chief critical range respectively.

Theoretical Considerations.—The two theories which have been advanced to explain the existence of these critical ranges in cold-worked metals are what may be called the allotropic theory due to Alkins, and the recrystallisation theory due to Ellis.

The allotropic theory advanced by Alkins is in support of the views of Cohen and his collaborators, that copper undergoes an allotropic inversion at 71 deg. C., the variety stable at normal temperature (α) changing to the variety stable above 71 deg. C. (β). The change is understood to be reversible, β reverting to α at ordinary temperatures. Cohen and Helderman* suggest that copper consists of a mixture of α and β at ordinary temperatures, the β variety undergoing a gradual reversion to the more stable α variety. Alkins suggests that hot-rolled copper necessarily contains β, in that, immediately cold-drawing begins, the change in properties proceeds at its maximum rate. Over the first half of the tenacity-deformation curve the change $\alpha \rightarrow \beta$ progresses, being assisted by the rise in temperature due to friction, there being "no period of induction" as in the case of the second change (critical range). The last portion of the curve (past the critical range) is not definitely explained. As Dr. Rosenhain has pointed out, the evidence upon which the alleged allotropy of copper is based is very slender. Moreover, there is much evidence to show that other metals and alloys exhibit critical ranges as well as copper. The recrystallisation theory of Ellis is based on a law of annealing founded on the work of Sauveur, Chappell, Robin and others, and framed by Hanson somewhat as follows: That for every degree of deformation (by cold work) there is a critical temperature of recrystallisation which coincides with an extremely rapid rate of crystal growth. Ellis proposes to apply this law to the amorphous phase produced by cold work (as first conceived by Beilby). He suggests that it is continually tending to recrystallise at all stages of deformation, and that it actually does recrystallise to an extent which increases as the deformation to which the material has been subjected increases. This recrystallisation, however, suffers a change in its rate when the critical range of deformation is reached.

Thus it is desired to extend the law to admit of the possibility of the temperature of working of the metal or alloy coinciding with the critical temperature of recrystallisation and rapid growth. The author has advanced the objection to this theory that cold-worked copper does not recrystallise when heated to a higher temperature than the mass reaches in the rolls, but while in the rolls the metal is under the influence of two other factors, viz., a strain gradient and a temperature gradient. Moreover, there is always the possibility of the momentary production of intensely local high temperatures in the amorphous phase regions, the aggregate effect of which would only succeed in raising the temperature of the whole mass 40 deg. or 50 deg. C. Therefore, on these grounds alone, the objections to Ellis' theory appear to be of a *prima facie* character. Other aspects of the phenomenon, however, have presented themselves during the author's investigations, which render an acceptance of this hypothesis difficult. It should be pointed out that Rosenhain has suggested a modification as the result of his study of iron following upon overstrain. He suggests that recrystallisation would not occur by the growth of new minute crystals; rather the disturbed atoms of the amorphous layer would re-establish themselves in the crystalline orientation of the crystal of which they originally formed a part, so that the disturbed regions rendered amorphous during the slipping process would be able to re-establish themselves, leaving perhaps a very thin film of amorphous material instead of the much thicker region first formed.

The author's conception of the structural alterations resulting from the application of uninterrupted cold work differs somewhat from those of the above-mentioned investigators. The chief facts to be borne in mind, and which must all be embraced in any theoretical consideration, are as follows:—

(1) The tenacity and hardness are increased by the application of cold work except at certain stages where, over a certain range, they remain constant. These may most conveniently be called "critical ranges of deformation." (2) Corresponding with these critical ranges there occur ranges of constant elongation (of test-piece) and (in cold rolling) ranges of constant width of strip. (3) So far as the available evidence goes, the "critical ranges" are ranges over which the specific gravity either decreases or remains constant and the elastic limit increases. It will perhaps be objected that the available evidence is inadequate, but its qualitative aspect cannot be ignored. (4) When rolled strips are sectioned laterally the hardness-deformation curves of the sections indicate a substantial decrease of hardness over ranges corresponding to the above-mentioned critical ranges.

Now, as the first application of work is to effect a very rapid rate of increase of strength and hardness, without much visible alteration of the crystalline structure, it may be assumed that the deformation proceeds by the movement of numerous lamellæ relatively to one another in each crystal grain, just as the individual cards in a pack move relatively to one another when they are suitably displaced. Some movement will also take place along conjugate slipping-planes.

The planes over which these lamellæ slide are known as planes of slip and give rise to the phenomenon first observed by Ewing and Rosenhain, of "slip-bands" on a polished surface of metal subjected to stress above the elastic limit. In each individual crystal, the angles which these planes of slip form with the plane of rolling will differ according to the orientation of the crystal, but the action of continued rolling is to displace the lamellæ until their etch-bands tend to form an approximately common angle with the plane of rolling. During the sliding of these crystalline lamellæ over one another there is a disturbance of the crystalline material, and according to Beilby, an infinitesimally thin layer of hard amorphous material is formed, having physical properties of a different order from those of the stable crystalline material. The birth of this amorphous material, its temporary mobility and final setting into hard, unyielding membranes may satisfactorily account for the plasticity, the increase of hardness and tenacity, and the retention of continuity of the metal. The phenomenon of the critical range of deformation has yet to be satisfactorily explained by Beilby's theory.

For, clearly, a theory which explains the hardening of metals when plastically deformed cannot, on the same premises, account for the failure to harden further under a continuation of the same kind of treatment. There will be little justification for assuming that the mobility of the amorphous phase is less temporary at those stages of reduction coinciding with the critical ranges than at others. It might be suggested that the surfaces of contiguous lamellæ are, when the first sliding takes place, covered with infinitesimally small serrations due to slip along conjugate planes, and move over one another with difficulty, like two panes of frosted glass, but that further slipping smooths over the surfaces so that they slide over one another more easily, like panes of clear glass. Thus, those parts of the tenacity-deformation curve having an upward trend would represent laborious slipping, in which the serrations were worn down and the amorphous phase was freely produced, and the horizontal portions would represent "smooth slipping" in which, temporarily, no fresh amorphous material was produced. The commencement of an upward slope in the tenacity-deformation curve would coincide with the inception of a fresh set of planes of slip.

But would this explanation account for a fall in specific gravity and for absence of lateral spread? The latter might be accounted for by assuming that, as the crystals become flattened out by movement along planes of "forward slip" (by which longitudinal extension is effected) and planes of "side slip" (by which lateral spread is effected), the former must greatly predominate and must have been subjected to considerably more smoothing action than the latter. Hence at a given stage in the reduction a large number of planes of "forward slip" are capable of "smooth slipping," whilst the planes of "side slip" have not yet reached that condition. Hence, over the critical range, the strip extends longitudinally with greater ease than laterally, no fresh amorphous material is produced, and therefore no increase in hardness or tenacity occurs. According to Möller,* the tenacity of rolled strips tested transversely is higher than when tested longitudinally. This might be attributable to the lack of "smooth-slipping" planes favourably situated in relation to the direction of the pulling force applied. Similarly, no decrease in percentage elongation occurs, and theoretically the specific gravity should remain constant. If a decrease in specific

* Proceedings of the *Koninklijke Akademie van Wetenschappen te Amsterdam*, 1913, vol. xvi, page 628; 1914, vol. xvii, page 60.

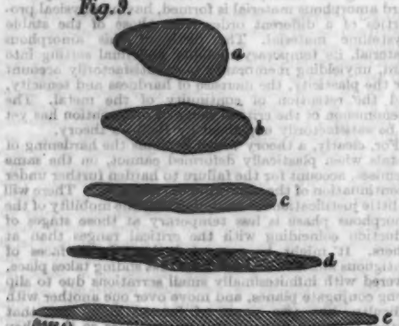
* *Loc. cit.*

gravity does actually occur, it could only be accounted for by the production of voids at terminal boundaries of the planes of slip.

The fact, if confirmed, that the elastic limit is lower at the commencement of a critical range than at the end would be explained by the preponderance of planes of "forward slip," whose career of "smooth slipping" was just about to commence. Slipping would commence at a lower tensile stress than after those "smooth-slipping" planes had been exploited by a further stage in the rolling process (or drawing). The question at once arises: How could this process of "smooth slipping" be arrested in order that a fresh set of planes might be brought into action? There are two possible answers to this question. In the first place it might be assumed that the directional action of the rolling process had brought each pack of lamellæ into such position that smooth forward slipping occurs only. This would involve an imposition of stress on the cellular intercrystalline material, which, subjected to elastic stress, in turn imposes a compressive restraint upon the unlimited slipping of the lamellæ which it circumscribes. For this reason or for the reason that the stepped surfaces of contiguous intercrystalline faces may mutually interlock, or for both, the "smooth-slipping" period is arrested and the elastic limit of the whole mass raised, because fresh displacement can only be effected by the bringing into action of a fresh set of slipping planes to be exploited in their turn.

Beyond a certain stage of reduction, the copper strip begins to show a decidedly laminated structure, and microscopic examination of a suitably polished and etched vertical section reveals the presence of sloping dark lines running roughly parallel with one another in any one crystalline lamina, and seemingly tracing the position of planes of "forward slip." At subsequent stages of deformation the laminated crystals are much thinner and longer, but the angles which the traces of the planes of slip (or "etch-bands") make with the plane of rolling are approximately unaltered. This might be explained in the following way, but this explanation postulates the re-orientation of each grain with respect to its neighbours, proof of which the author does not possess. The rough sketches are meant to represent vertical longitudinal sections of a single crystal grain at successive stages of deformation. The parallel lines represent planes of preferential slip, which are forced to form a gradually lessening angle to the plane of rolling. At stage *c* the critical angle at which "smooth slipping" commences has been reached. At stage *d* the "smooth-slipping" movement has terminated and a new set of conjugate slipping-planes (the old ones are now shown dotted) are brought into action. "Hard slipping" of these new faulting planes now takes place, until they in their turn approach the critical angle as shown in *e*. The sketches (Fig. 9) represent the conjugate planes as being at right angles to the other planes of slip. This

Fig. 9.



is very improbable, as it is practically certain that the planes of slip follow octahedral cleavage planes, in which case the angle would be approximately 30 deg. and not 45 deg. This angle would not be altered by the process of producing a directional arrangement of the lamellæ, thus substituting a semi-homotropic condition for the original haphazard orientation of the crystals in the annealed bar.

During the stage *d* to *e* there has been a renewal of displacement along the planes of "side-slip," resulting in lateral spread. The resistance offered by the metal during the "hard-slipping" stages may be partly due to the stepped outlines produced by faulting by the conjugate slipping planes.

A photomicrograph shown by the author apparently represents the faulting of Neumann lamellæ due to deformation, in a sample of β brass, which had been reduced to 50 per cent. of its original thickness by cold rolling. The author suggests that possibly the displacement along planes of slip is analogous to the action which has taken place in this one crystal of β brass, along Neumann planes. It is interesting to observe that if these are Neumann lamellæ that are found in ferrite and in β brass, neither of which exhibits "twinning" after deformation and annealing, it is possible that the regularly-oriented "etch bands" may have resulted from the integration of a large number of minute planes of slip which, in the course of rolling, have formed by "stepping" over from one lamella to another and thus represent continuous yet serrated planes across the crystalline lamina. The author's colleague, Mr. T. P. Colclough, M.Sc., suggests that these planes probably coincide with the angle of maximum shear, their location being revealed by etching.

Dr. Rosenhain referred on a former occasion to the behaviour of iron following upon overstrain. When iron which has been strained appreciably above the yield-point is tested by means of an extensometer, it is found to be slightly plastic even under quite small loads, so that the stress-strain diagram, even for stresses of only 4 tons or 5 tons per square inch, is no longer a straight line, but a curve, and the material undergoes permanent extension even under such small stresses. By allowing the iron to rest, however, for a few days, or by heating to 100 deg. C. for a few minutes, its semi-plastic state disappears. The elasticity is recovered and the yield-point raised to the neighbourhood of the highest stress previously applied. Professor F. C. Lea* has also drawn attention to some practical aspects of this phenomenon. Professor C. A. Smith has shown that the influence of heating to 100 deg. C. is to lower the elastic limit of over strained copper. It cannot be to the time effect that the rise in the elastic limit over the critical range, as described by the author, is due. The specimens were all tested at the same time. If the specimens having low elastic limits (at the beginning of a critical range) be suspected of possessing this semi-plasticity, then a period of rest of five months has not succeeded in removing it. Finally, the author wishes to point out that the whole subject of plastic deformation is very abstruse, and the difficulties of drawing conclusions great. He has therefore put forward his views tentatively with the object of obtaining helpful criticism, particularly upon the central idea that the critical range of deformation is due to "smooth" slipping along preferential planes of slip, whilst increases in hardness and tenacity are due to simultaneous slipping along planes of "forward" and lateral slip, on which the amorphous phase is generated.

THE AIRCRAFT DYNAMOMETER HUB.†

In this article it is proposed to deal with the details of construction of a dynamometer hub as used at the present time. This device is fitted on to the extension of the crankshaft instead of the usual propeller hub, and carries the propeller in such a way that the propeller is in the same position as with the usual method of fitting. The dynamometer hub consists of gauges with automatic regulation fitted between the two main parts of the device, moving independently one of the other; one of these is connected to the crankshaft and the other is connected solid to the propeller. These gauges are the most suitable of any type of dynamometer for the required purpose owing to the following three reasons:—

1. There is no lost motion in the gauges. The gauging devices and parts transmitting the forces are not displaced relatively to one another with varying loads.

(2) No spontaneous oscillations occur.

(3) The method of construction damps out the forced oscillations (generated especially by the crankshaft and propeller).

These advantages are of greatest importance, as in this method the heavily oscillating forces generated by the engine act on the dynamometer hub without being balanced by any flywheel mass and measurements in these circumstances are only rendered possible by those advantages.

The automatically regulated gauge invented by Professor Dr. Bendemann‡ is illustrated in Fig. 1 in its most usual form. It consists of a cylinder *a* closed at one end, in which is a light piston *b* which must be a good oiltight fit in the cylinder. External forces are transmitted to the piston through a tappet *c*. An oscillating lever *d* is fitted on the top of the cylinder. This lever passes between two collars on the tappet, and each end is connected to the regulating pistons *e* and *f*, fitted into holes bored through the cylinder. When a load impresses itself on the tappet, the piston is depressed. The regulating piston *f* then allows a fluid under pressure to flow into the cylinder from *g* until the piston *b* is forced up again.

The movement of the piston causes the regulating piston *f* to reduce the passage for the fluid gradually, until the piston has resumed the position illustrated, when the passage is completely closed by the regulating piston. The pressure under the piston is then proportional to the load acting on the piston (if the friction on the piston is not taken into consideration) and can be gauged by means of a manometer fitted at *h*. The same process occurs when there is a loss of compressed fluid through leakage. As the load acting on the piston decreases, the compressed fluid flows back under the piston through *h*. (All manometers in use act on the principle of change of volume.) The piston rises and the regulating piston *e* allows the fluid to flow out freely until the initial position is reached.

If sudden alterations of the load acting on the piston are not taken into consideration, the stroke of the piston is very small, it being determined by the position of the regulating pistons and the transmission of the lever. It is possible so to reduce the stroke as to render the movement negligible. The piston then remains constantly in the working position of the gauge. If two or more gauges are required to measure the same force together, only one regulating piston is required, the compression chambers being all connected.

The advantages of this device as mentioned above—freedom from oscillations and damping-out action—reach a maximum when the regulation of the outward flow is discarded (by which an economy of oil is also effected) and when compressed oil free from air is used. Machine oil absorbs a large quantity of air when subjected to compression. The lowest quantities found by tests carried out at a temperature of 20 deg. C. are given in the following table:—

Table I.

Compression	1	2	3	4	5	8	12	20	27	31 atm.
Air obtained in percentage of volume at 1 atm.	30	40	48	52	55	58	59	64	69	70 p.c.

These figures show that the compression must not be produced by means of compressed air but by means of a pump, and that no air must be allowed to come into contact with the oil whilst it is under pressure.

The main parts of the dynamometer hubs, Figs 2 and 3, are the cone, the hub proper, the gauge housing, and the plug; to these must be added tubing, recording instruments, pressure oil pump, &c.

The cone piece *a* is keyed on to the crankshaft extension and secured by means of a nut. It is cylindrical in section along the part where the hub is usually fitted, and the hub proper *b*, which carries the propeller instead of the usual hub, fits freely round it. The mounting containing the gauges is fitted into the forward extension of the cone beyond the hub. In order to satisfy the need for symmetry there are two thrust meters and two torque meters. The axes of the thrust meters *c* lie parallel to the axis of rotation; the torque meters *d* are so fitted that their axes are tangential to a circle at right angles to the main axis, the centre of which is on the axis of rotation; in this way the torque is transmitted to the meters directly. There are two lugs *e* on the hub *b*, which are opposite the torque meters when correctly located relatively to one another. Tappets *f* transmit the forces from the torque meter to these lugs, and the tappets *g* of the thrust meters also transmit the forces to the hub. A connection between the revolving meters and a stationary pressure gauge and recording instrument is carried out by means of a so-called plug *h*, a comparatively long piston fitting exactly into a cylinder *i*. Holes are drilled lengthwise in the plug equidistant from one another and from the edge, the number of grooves varying with the number of connections for the compressed oil required. These grooves connect up with holes bored into the plug radially. The holes of the plug form a connection with the gauges; the slots in the plug are connected to the manometer tubing, so that continuous circulation of the compressed oil through both these grooves can be obtained. This device is fitted in front of the meter housing, as it requires a free length of shaft.

As with various sizes of engines the cone must be altered in order to fit the crankshaft extension and the hub must correspond to the propeller, in the actual dynamometer hub (Figs. 4 to 7) that part of the cone in which the meters are fitted is carried out as a separate meter housing and is only connected to the other part of the cone by means of a toothed coupling, so that the housing is removable.

The meter housing is the most expensive part of the dynamometer hub owing to the various parts fitted to it, such as the meter pistons and regulating device, &c. By constructing the housing as a separate part its range of application is increased and the selection of suitable material is rendered easier. These advantages outweigh the increased cost of the detachable connection and the consequent increase in weight. In order to enable the required dimensions to be obtained chrome-nickel steel was finally chosen as the material for the cone *a* after several tests had been carried out, owing to the stresses to which this part is subject. Its cylindrical and conical surfaces are hardened and ground. The cylindrical surface extends practically over the whole length, and it is on this surface that the hub proper is mounted. Slots *b* and grooves are provided in the cone for lubrication. The tooth coupling *d* is fitted on to an extension *c* in front in the shape of a flange. A recess is provided to take the nut *s* securing the hub and the locking ring.

The hub is a good sliding fit on the cone; it is made of cast steel, its external shape being somewhat complicated owing to its locking flange. The dimensions of the hub are determined by the height, diameter, and bore of the propeller boss and the position and size of the boss bolts, whilst the diameter of the inside cylindrical section is determined by the size of the cone. The locking flange fits on the serrations of the hub in the usual way. The friction surface of the hub is lined with white metal. Hardened tool steel sockets, into which the hardened steel tappets are ground, are inserted in the lugs transmitting the torque, and slots, Figs. 5 and 6. The play between the hub proper and the cone is limited in the direction opposed to that of the momentary impulse by stops; in the direction of the axis by two teeth *l* cast on to the torque lugs which form a kind of bayonet catch behind the flange of the cone (Fig. 6); in the direction of rotation by two lugs *m* cast on and engaging with two bars *n* on the meter housing. The accurate adjustment of the dynamometer hub is ensured by two adjustment marks s_1, on the flange and s_2 on the lugs *k*.

The shape of the meter housing depends on the size and position of the torque-meter pistons. They must not only be exactly opposite the corresponding tappet sockets, but they must also be so placed that the centrifugal forces of the pistons and oil do not influence the measurements. For instance, should a piston with a plane head, the radius of which is *r* and the area F, rotating about an axis O (Fig. 8), with an angular velocity ω, be under the influence of a column of liquid reaching to the axis of rotation the specific weight of which is γ/g, this column of liquid applies to the piston a force—

$$P = G_1 F_1 \left[\frac{\omega^2}{2} \cdot \frac{(r)^2}{(2)} \right]$$

* Engineering, 1915, vol. c, page 1.

† Extract from the 18th Report of the "Deutschen Versuchsanstalt für Luftfahrt," issued in Technical Memorandum No. 19, by the Controller of Information, Department of Controller-General of Civil Aviation, Air Ministry.

‡ German patent 275,983. cf. T.D., vol. i, No. 1, page 61.

when $c = \frac{\omega^2 \cdot \gamma}{2g}$ and $a + b$ have the meaning shown in Fig. 8.

Should a depression be made in the piston head the capacity of which would be V, its centre of gravity S_v being at a distance s from the head of the piston, then—

$$P = c\left[F(a^2 + b'^2) + \frac{(\gamma)_2}{(2)} + V(2s - a - \mu)\right],$$

where

$$\mu = \frac{V}{F} \text{ and } b' = b - a$$

Both these expressions show that the force P depends on b or b', that is, from the position of the piston in the cylinder. Besides this force, a partial force Z_d of the centrifugal force Z of the piston acts on the centre of gravity S_z of the piston (the weight of which is G_z), so that we have

$$Z_d = G_z \cdot \frac{\omega^2}{g} \cdot d = G_z \cdot \frac{\omega^2}{g}(b + e),$$

where d and e have the meaning shown in Fig. 8.

Fig. 1. PROF. DR BENDEMANN'S GAUGE, WITH AUTOMATIC REGULATION.

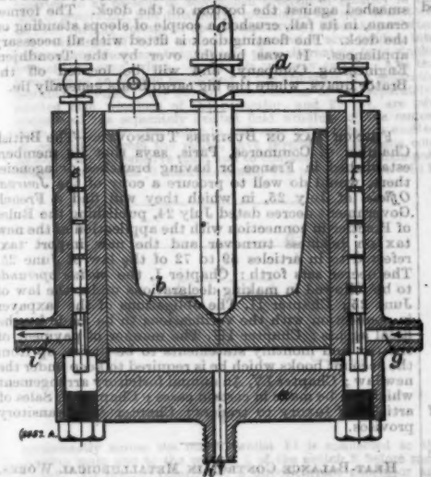
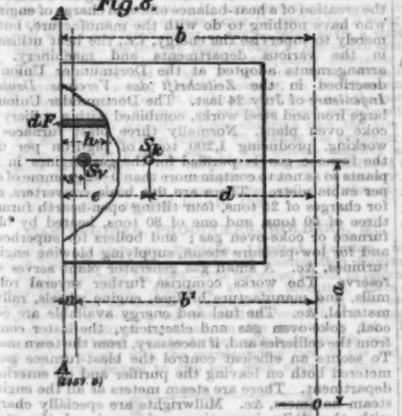


Fig. 8.



These two disturbing forces act in opposite directions. If P and Z_d are equal, then b can be so determined that the disturbing forces cancel one another, and in this way the disturbing influence of the centrifugal forces is entirely avoided.

In order to keep forces P as small as possible, the gauge cylinders are closed at the end by a cover o secured by a circular nut p (Figs. 5 and 6), and the space under the piston is filled with oil, the oil penetrating to the axis of rotation through slots q. In order to enable the tappets and pistons to act on each other the covers are made oiltight round the corresponding extensions of the piston. In this way the cancellation of the disturbing forces P and Z_d only comes into consideration for the less area caused by the letting in of the cover, as also for the thickness of the piston head. The covers protect the cylinders from dirt and grit. The pistons are made of tempered steel and their weight is reduced as far as possible. The regulating pistons of the torque meter are immediately connected with the pistons by means of circular nuts. There being no regulation of the outward flow in these gauges, no control rods are required.

The ends of the thrust-meter cylinders, Fig. 5, are also closed by covers and the intermediate spaces are filled with oil. It is worthy of note that the compressed oil delivered through the regulating pistons is not obtained from the pressure oil pipes but from the pressure chamber of the adjoining torque meter through a slot r (Fig. 6). In this way both the gauging systems are connected in sequence, this being rendered possible by the fact that the gauging pressure in the thrust meters is constantly lower than in the torque meters.

The gauge housing can only be produced by casting owing to its complicated external shape necessitated by the arrangement of the meters. Grey iron was chosen for the construction of the housing, as copper alloys were out of the question owing to the urgent necessity of economy in these metals and if cast steel had been chosen special bushes for the pistons would have been necessary. In the centre of the housing is an annular body with the teeth of the coupling at the rear end and the fitting for the plug in front. The two cylinders of the torque meters are fitted on the annular part and are strengthened by means of central ribs. In this way a T-shape is given to the critical cross-section for the force to be transmitted by the gauge, and is stressed in such a way that the material most liable to failure under tension is also compressed.

In the case of the thrust meters the cylinders are so fitted on the central ribs that these form the bottoms of the thrust meter cylinders. Here also sufficient strength of the cross-section required to take up the forces is obtained by means of ribs. Rods s are provided on the cylinders of the torque meters to act as stops for the lugs m on the nose-piece. These stops come into operation when the torque becomes negative or it is required to disconnect the dynamometer hub when oil is being fed into the torque meter for the regulation. The pressure oil tube is connected at t_1, the gauging tubes at t_2 and t_3, whilst the torque meters are connected together at t_4 and t_5 and the thrust meters at t_6 and t_7. The meter housing is secured to the cone by means of an end plate provided on the annular part of the housing, the shaft of the hollow securing screw v being passed through the opening in the plate and screwed into the nut s of the hub. The head of the screw, provided with a locking ring w, then comes in contact with the end plate, securing the housing and also taking up the thrust of the propeller. The pitch of the thread of the hub nut is always higher than that of the crankshaft.

The plug is made of phosphor bronze and is screwed on to the gauge housing by means of a flange and circular nut. At the same time it closes the inside of the housing filled with oil.

There are three grooves inside the plug which at t_8, t_9 and t_{10} connect with small tubes leading to the points of connection t_1, t_2 and t_3 on the housing. The stationary plug is made of tool steel; it is pierced with four slots, one of which goes through the whole length.

Copper tubes of 3 mm. inside diameter are fitted to the head of the plug, one of these being for the compressed oil, two transmitting the gauging pressure for the torque and thrust and the fourth tube being connected to the long slot. Oil is led through this tube to the inside of the gauge housing and from thence under the piston of the gauge or between the cone and hub proper. This supply of oil is regulated by means of a cock.

A safety rupturing device is fitted on to the head of the plug, which prevents any part of the dynamometer hub from getting out of order, or from coming into contact with the propeller, should the plug jam. For this purpose the copper tubes are led through a sheath mounted on ball bearings and along a lever attached to this sheath. A wire of a fixed breaking strength—70 to 80 kg.—is stretched between the sheath and lever. Under the usual working conditions this wire takes up the torque of the plug friction. Should this friction exceed a certain magnitude the wire breaks, and the tubes are cut off in the sheath and the sheath continues to revolve on the ball bearings with the plug.

MAIN PARTS OF THE DYNAMOMETER HUB.

Fig. 2. SECTION A.B.

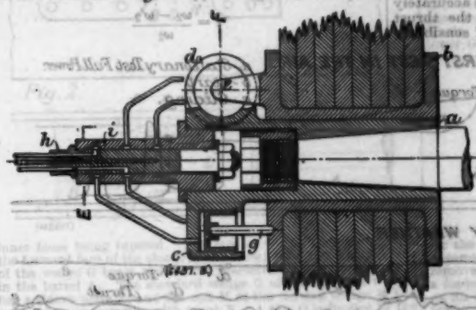
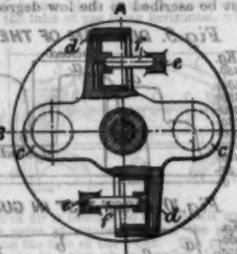


Fig. 3. SECTION E.F.



DETAILS OF DYNAMOMETER HUB.

Fig. 4. SECTION A.B.

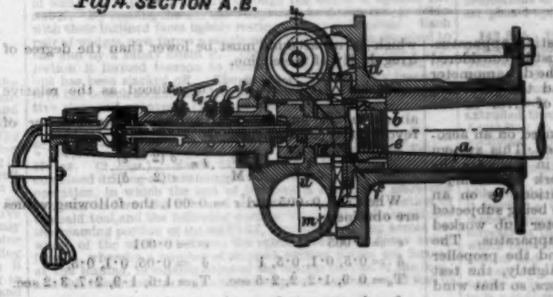


Fig. 6. SECTION E.F.

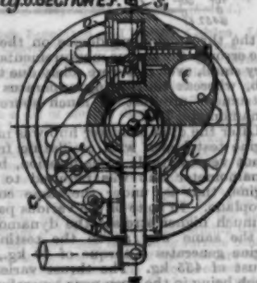


Fig. 5. SECTION C.D.

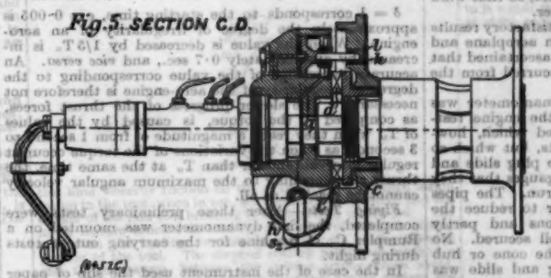
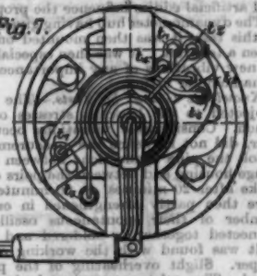


Fig. 7.



The plug being a new part was carefully tested whilst in use for frictional resistance, reliability of transmission of pressure, and leakage. It was ascertained that the torque due to friction was from 0·1 kg. to 0·25 kg., the transmission of pressure was perfect, and under usual working conditions the loss of oil through leakage for each oil-tight surface amounted to 25 cub. cm./hr. when 40 is the degree of fluidity of the oil (according to Engler). The total consumption of oil for the hub can be divided as follows:—

	Cub. Cm./Hr.
Thrust meters	60
Torque meters	100
Recording instrument	10
Plug	50
Tubing (about)	30
Total	250

The tubes are led to the recording stand from the lever on the plug. As a rule the tubes are carried round the propeller to the engine on a bracket made of thin walled tubing, and from thence to the recording stand. All the accessories required for the dynamometer hub-pump, air chamber, oil tank, oil distribution system for regulation and lubrication, recording instruments are fitted in a small table, easily carried on the machine.

Tests with the Dynamometer Hub.—The dynamometer

hub was first of all fitted to a propeller testing apparatus driven by an electric motor with oscillating frame. The friction of the oscillating frame amounts to about 0·5 kg., and is comparatively high for low performances. With increased performance the loss incurred through the increased oscillations from the increased number of revolutions is not only proportionally but actually smaller, and with a torque of from 60 kg. to 80 kg. the loss is so small that no influence can be detected by ordinary means. The electro-motor can be regulated to a special torque by varying the field voltage. This requires some practice as the practically instable frame oscillates constantly.

The largest error in the measurement of thrust amounts to ± 5 kg. In order to calibrate the dynamometer hub, the torque was increased by 10 kg. from 30 kg. to 90 kg., the engine revolutions were regulated correspondingly, and the thrust was only gauged from 50 kg., as with a lower torque the inaccuracy is too great. The diagrams recorded during this calibration test are separated by about 34·5 mm., corresponding to the arrangement of the recording pencils. In order to curtail any unnecessary length of the chart, the recording mechanism was constantly stopped during adjustment.

According to this the error amounts on an average to about 0·5 per cent. for the torque and 1·3 per cent. for the thrust measurements. As there is no reason why the dynamometer hub should gauge the thrust less accurately than the torque, the greater inaccuracy in the thrust values must be ascribed to the low degree of sensibility

Fig. 9. DIAGRAM OF THE FIRST TEST IN THE AIR.

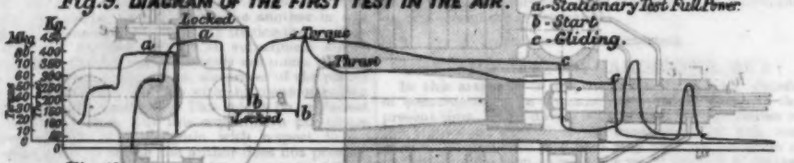
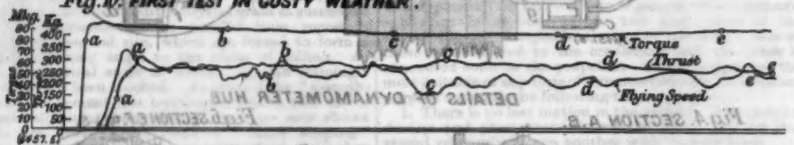


Fig. 10. FIRST TEST IN GUSTY WEATHER.



of the thrust gauging device on the testing apparatus. The error in the torque measurements must be considered very small, even if it were solely due to the dynamometer hub, whereas the testing apparatus and the recording instrument are just as much sources of error as the dynamometer hub.

Later the dynamometer hub was mounted on an aero-engine test bench with oscillating frame. This system is not very suitable to calibration, but in this case the dynamometer hub was required to work on an aero-engine, that is, under the same conditions as on an aeroplane. In spite of the various parts being subjected to much higher stresses the dynamometer hub worked in the same way as on the testing apparatus. The engine generates a torque of 80 kg., and the propeller thrust of 455 kg. The thrust varies slightly, the test bench being in the open near several others, so that wind and artificial eddies influence the propeller.

The dynamometer hub having given satisfactory results in this test, it was then mounted on an aeroplane and given a test run. It was then especially ascertained that no new vibrations of any importance occurred from the dynamometer fitting.

Knowledge Gained by Tests.—The dynamometer was subjected to the heaviest stresses on the engine test-bench. Considerable vibrations occurred which, however, did not influence the measurements, but which so shook the pipe connections between the plug slide and gauge housing and between the pairs of gauges that they broke after 20 minutes' to 60 minutes' run. The pipes were then partly strengthened in order to reduce the number of their spontaneous oscillations and partly connected together or soldered and well secured. No fault was found with the working of the cone or hub proper. Slight overheating of the plug and slide was noted. The safety rupturing device came into action once or twice as the plug fitted too closely. Each time it was successful in preventing any damage being done to the plug or slide, so that the plug could be removed by hand. Since then every plug undergoes torque tests before being fitted.

The diagram shows that with sudden variations of the load the thrust varies less quickly than the torque and increases more slowly. This is a consequence of the inertia of the mass of the propeller and of the hub proper, for the acceleration of which a part of the engine performance proportional to the inertia must be used. The time which elapses between the disturbance of an existing state of equilibrium by a variation of the torque and the recovery of equilibrium must be taken into consideration when drawing up the diagram. The moment of inertia of the rotating masses, i.e., the propeller and hub proper, is used to determine this interval T_u as the torque is gauged between the hub proper and the cone. In the case of a 160-h.p. hub with an "Eta" propeller, it was found by the well-known pendulum method that $I = 0{\cdot}49$ kg.-sec.[2] As the moment of inertia of the revolving engine driving gear, including the connecting rod parts* is known to be about 0·008 kg./sec.[2], that is about 1·6 per cent. of the moment of inertia of the propeller, the following calculation can also be applied to aero engines with a rigid hub.

In the case of propellers we can write with sufficient accuracy, $M_1 = m \cdot \omega_1^2$, where M_1 is the torque with angular velocity ω_1 and m the torque when the angular velocity equals 1 to be ascertained by tests. Should the torque increase to M_2, whereby the angular velocity can also be increased to ω_2 during the passage from ω_1 to ω_2, with an intermediate angular velocity ω and the corresponding torque M an extra torque is produced:

$$M_u = M_2 - M = m_1 (\omega_2^2 - \omega_1^2)$$

therefore the angular acceleration at this point becomes—

$$\frac{\delta \omega}{\delta t} = \frac{m_u}{J} = \frac{m}{J} \cdot (\omega^2 - \omega_1^2).$$

If we integrate between the limits ω_1 and ω'_2 we obtain the time of the interval,

$$T_u = \frac{J}{2\,m \cdot \omega_1} \int \frac{\omega_2' + \omega}{(\omega_2' - \omega)} \int \frac{\omega_2'}{\omega_1}$$

as a logarithmic function from whence we obtain $T_u = 0$ when $\omega'_2 = \omega_1$.

In order to obtain a standard by which to judge of the process, a degree of approximation must be introduced

$$\varepsilon = \frac{\omega_2 - \omega'_2}{\omega_2}$$

which on no account must be lower than the degree of irregularity of the engine.

Further $\delta = \frac{\omega_2 - \omega_1}{\omega_2}$ is introduced as the relative alteration of angular velocity or of the number of revolutions, from whence

$$T_u = \frac{J\,\omega_2}{2\,M_2} \cdot l\,n\,\frac{\delta\,(2-\varepsilon)}{\varepsilon\,(2-\delta)}$$

When $\varepsilon = 0{\cdot}005$ and $\varepsilon = 0{\cdot}001$, the following values are obtained:—

$\varepsilon = 0{\cdot}005$	$\varepsilon = 0{\cdot}001$
$\delta = 0{\cdot}5, 0{\cdot}1, 0{\cdot}5, 1$	$\delta = 0{\cdot}05, 0{\cdot}1, 0{\cdot}5, 1$
$T_u = 0{\cdot}9, 1{\cdot}2, 2, 2{\cdot}5$ sec.	$T_u = 1{\cdot}6, 1{\cdot}9, 2{\cdot}7, 3{\cdot}2$ sec.

$\delta = 1$ corresponds to the starting time, $\varepsilon = 0{\cdot}005$ is approximately the degree of irregularity of an aero-engine. When the value is decreased by 1/5 T_u is increased by approximately 0·7 sec., and *vice versa*. An accurate knowledge of the value corresponding to the degree of irregularity of the aero-engine is therefore not necessary.* The slower progress of the thrust forces, as compared to the torque, is caused by the values of T_u when they reach a magnitude of from 1 second to 3 seconds, as when the variations of the torque occur at regular intervals shorter than T_u at the same time, the thrust corresponding to the maximum angular velocity cannot be reached at all.

Flying Tests.—After these preliminary tests were completed, the first dynamometer was mounted on a Rumpler C. IV machine for the carrying out of tests during flight.

In the case of the instrument used the slip of paper moved at a speed of 10 mm./sec., and the instrument was fitted with two pencils set 34·5 mm. apart, the range of each pencil being 30 mm.

The first flying test was carried out on November 7, 1916, in clear and calm weather. It lasted about 15 minutes, and a height of 800 mm. was attained. The results are shown in Fig. 9, shortened to scale (with the exception of the stationary test). The whole of the torque curve resulted in a heavy line, as the pencil also recorded the torque impulses of the engine in part. Before the flight a short test run *a* was carried out with $n = 1{,}000$ r.p.m., and also at full throttle.

On the engine being throttled down at the start with the dynamometer hub "locked," the torque curve rose to the maximum height the instrument is capable of recording. On the dynamometer hub being switched on to the gauging position as the aeroplane left the ground, a rise in both curves at (*b*) was recorded. As the value of the thrust rose to its maximum, where it remained, the thrust curve rose, but fell to a fixed level as the speed was increased. Both values decreased with increasing altitude. On the engine being switched off as the machine went over into a gliding flight a sudden fall in the curves at (*c*) was recorded. When near the ground the throttle was opened out again, and then the engine cut out again. The result is clearly visible in the diagram. The diagram obtained from a flying test carried out on April 3, 1917, a gusty day, is reproduced in Fig. 10. In this case the speed of the aeroplane was also obtained by means of a pressure disc.† The diagram shows clearly the influence of the various gusts in the thrust, from which the importance of obtaining a record of the speed of the aeroplane can be realised.

NEW DOCKS IN NORWAY.—The new dry dock of the Aker Engineering Company is now ready; an experimental docking has already taken place and the new dock is about to be opened for regular use. Northern Norway has recently been supplied with its first floating dock which is able to accommodate vessels up to 10,000 tons deadweight. It was purchased in Germany last year and was expected to be delivered last autumn, but there were difficulties about getting it out of Germany, and both London and Paris had to be communicated with in the matter. It took two tug boats a fortnight to tow it from Germany; one of its large cranes went overboard in a severe gale off the Skaw and the other broke and was smashed against the bottom of the dock. The former crane, in its fall, crushed a couple of sloops standing on the deck. The floating dock is fitted with all necessary appliances. It was bought over by the Trondhjem Engineering Company, and will be located off the Bratôr quays, where the big cargo boats generally lie.

FRENCH TAX ON BUSINESS TURNOVER.—The British Chamber of Commerce, Paris, says that its members established in France or having branches or agencies there, would do well to procure a copy of the *Journal Officiel* of July 25, in which they will find a French Government decree dated July 24, publishing the Rules of Practice in connection with the application of the new tax on business turnover and the new import tax, referred to in articles 59 to 72 of the law of June 25. The decree sets forth: Chapter I, the *modus operandi* to be followed in making declarations under the law of June 25; Chapter II, The obligations of the taxpayer in connection with the verifications to be made by the fiscal agents; Chapter III, The manner of payment of the tax and monthly statements to be drawn up from the account books which he is required to keep under the new law; Chapter IV, An annual forfeitory arrangement which can be made in certain cases; Chapter V, Sales of articles of luxury to traders; Chapter VI, Transitory provisos.

HEAT-BALANCE CONTROL IN METALLURGICAL WORKS.—The necessity for strictest economy during and after the war has in some of the German metallurgical works led to the creation of a heat-balance office, in charge of engineers who have nothing to do with the manufacture, but are merely to supervise the energy, i.e., the heat utilisation in the various departments and machinery. The arrangements adopted at the Dortmunder Union are described in the *Zeitschrift des Vereines Deutscher Ingenieure* of July 24 last. The Dortmunder Union are large iron and steel works, combined with a colliery and coke oven plant. Normally three blast furnaces are working, producing 1,200 tons of pig-iron per day; the furnace gas is purified for the gas engines in two plants so as not to contain more than 0·02 gramme of dust per cubic metre. There are five basic converters, each for charges of 25 tons, four tilting open-hearth furnaces three of 60 tons, and one of 80 tons, heated by blast-furnace or coke-oven gas; and boilers for superheated and for low-pressure steam, supplying blowing engines, turbines, &c. A small gas generator plant serves as a reserve. The works comprise further several rolling mills, and manufacture bridges, engine wheels, railway material, &c. The fuel and energy available are coke, coal, coke-oven gas and electricity, the latter coming from the collieries and, if necessary, from the town mains. To secure an efficient control the blast-furnace gas is metered both on leaving the purifier and on entering a department. There are steam meters at all the engines, steam hammers, &c. Millwrights are specially charged with the daily inspection and repair of the steam pipes. The direct combustion of coal is gradually being restricted, and the boilers are utilised somewhat on the lines of the accumulators of an electric plant, being as a rule heated by the gas which can be spared from the engine supply. The boiler flue gases are controlled by Orsat apparatus. The heat engineer is every day supplied with some 50 tapes of automatically-traced diagrams, &c., as well as with the records of the foremen on the consumption of fuel and energy, speed, length of run, and is thus able to report on irregularities in the efficiency which can only be deduced from a correlation of the various data. The control engineer, who is placed directly under the general manager, is specially trained for his duties, and he may indeed prove a valuable addition to the staff. At the same time it is clear that the control will involve a great deal of reporting and booking, and possibly red tape, which might find friends in Government departments rather than among practical men. We should add that the *Verein Deutscher Eisenhüttenleute* has organised a central heat office at Düsseldorf, which will hold a first general meeting of heat engineers at Berlin in September.

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* Tolle, "Regelung der Kraftmaschinen" (Regulation of power engines), 2nd edition, page 116.

* For accurate determination, see Tolle's "Regelung," &c., and Kolsch, "Gleichgang und Massenkräfte bei Fahr- und Flugzeugmaschinen" (Regularity and forces of the masses in ship and aero-engines).

† Hoff. New recording instruments for measurements of forces and ascertainment of tensile strength of bracing wires during flight. *Zeitschrift für Flugtechnik*," &c. 1914—pages 21, 142.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

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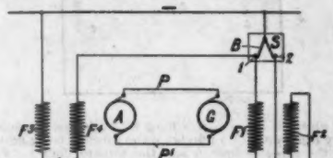
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

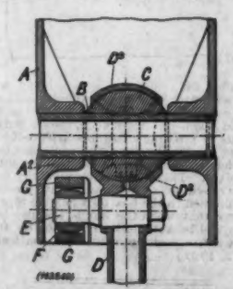
143,980. G. Stirk, Halifax, and J. G. Stirk, Halifax. Motors and Generators. (1 *Fig.*) March 10, 1919.—The invention relates to the simplification of connections and switch gear for separately excited direct-current electric motors and generators. In lieu of reversing field connections as is commonly resorted to at present to accomplish reversal of polarity in the case of generators, and direction of rotation in the case of motors, and for varying voltage or speed respectively, separately excited field windings of both motor and generator are divided into sections and these are brought into play alternately by a single-pole change-over switch, or a simple two-way switch. A is the armature of an electric motor and G the armature of a generator working together. F^1, F^2, are two sections of the separately-excited field windings of the generator, and F^3, F^4, are two sections of the separately excited field windings of the motor. Both windings F^1, F^2, being in this case independently excited or connected across the mains, have reversed connections connected with the positive main and to contacts 1, 2, of single-pole change-over switch S connected with the negative main. F^3 is



permanently across the mains, whilst F^4 is connected to the positive main and to the contact 1 of the switch S before mentioned. To reverse polarity of a direct-current generator and thereby reverse direction of rotation of the motor to which it is supplying current and to vary the speed of the latter, assuming the generator to be in motion by any convenient means either belt, alternating or direct-current motor, the switch bar B being in contact with 1 and direct mains + and − being alive, a circuit is completed from the positive main through F^1 and switch arm B to negative main. The generator consequently generates an electromotive force and P and P^1 are positive and negative respectively. A second circuit, however, is simultaneously completed through F^4, arm B, to the negative main, and the motor rotates in clockwise direction at minimum speed corresponding to maximum field strength. Upon changing over the arm B to 2 a circuit is completed through F^2, causing the generator to generate opposite polarity and P, P^1, become negative and positive respectively. The motor field remains unaltered in polarity, but is reduced in strength because F^4 is not now in circuit, consequently the motor rotates anti-clockwise at an increased speed. (*Accepted June 16, 1920.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

143,640. Alphaero Engines, Limited, London, and P. T. Houston, London. Internal-Combustion Engines. (5 *Figs.*) February 28, 1919.—The invention relates to internal-combustion engines. According to the invention, there is combined with an ordinary gudgeon pin fitted in the usual manner to the piston, a ball mounted thereon, which is engaged by a parti-spherical small-end on the connecting rod. For example, the latter may be formed with a detachable cap, the interior of which, with the corresponding face of the rod, is formed parti-spherical to grip and work upon the ball. The



piston A is formed with lugs A^2 for the reception of a gudgeon pin B, upon which is mounted the ball C, which is formed in one piece and threaded upon the gudgeon pin. This ball is engaged by the small-end of the connecting rod D, which is provided with a parti-spherical seating at D^2 and a cap D^3 secured by screws. The cap has also a parti-spherical seating, so that the ball is enclosed in a working bearing, but it and the piston A can rock in any direction in relation to the connecting rod D. The latter is provided with a projection E, carrying a partial ball F lying in a parti-spherical bearing in a slide G which can move vertically in relation to the piston, in lugs thereon. Thus as the connecting rod rocks upon the ball in a plane at right angles to the axis of the gudgeon pin B, the piston also twists. (*Accepted June 9, 1920.*)

GUNS AND EXPLOSIVES.

143,611. H. W. Gabbett-Fairfax, London. Machine Guns. (3 *Figs.*) February 24, 1919.—In order that the barrel may be quickly assembled in the breech sleeve or body, and readily detached therefrom, the barrel is mounted in a breech sleeve or socket, and provided with grooves or slots in the barrel and sleeve, each groove in the barrel forming with the corresponding groove or slot in the sleeve a complete mortice or socket, into which a pair of wedges is inserted. By tightening the wedges the barrel is firmly keyed into the sleeve, and after slacking off and withdrawing the wedges the barrel may be immediately removed. The barrel A is carried in the breech socket B, which is attached to the side plates C, C, forming part of the gun framing. The barrel A has formed on each side of it external grooves D, D, corresponding to internal grooves E, E, formed in the socket B. Wedges G, H, are inserted in these grooves and slots in pairs, the outer faces of each pair being parallel and the

Fig. 1.

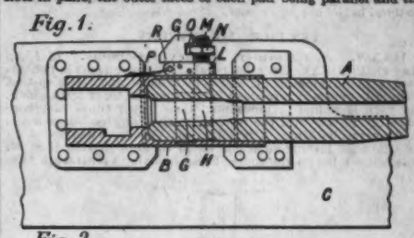
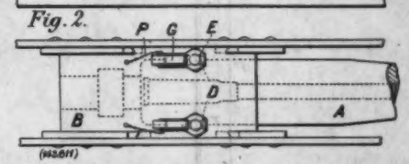


Fig. 2.



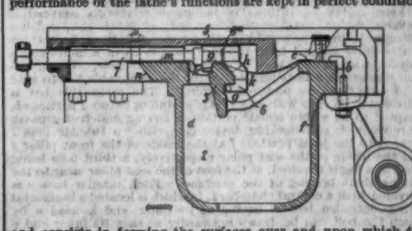
inner faces being tapered. The face of wedge H bears against the forward face of the slot E in the breech socket B, and the face of the wedge G bears against the rearward face of the groove D in the barrel A. The standard wedge G of each pair of wedges has a sleeve plate L, and the end M of the moving wedge H has screw threads engaging with a nut N. A slot O is formed in the head of wedge G. The wedges are assembled as follows: The nut N is held in position in the slot O, while the screwed end M of wedge H is pushed upward through the sleeve L against the nut N. By turning the nut the wedges can be drawn into position with their inclined faces lightly resting against each other. Each pair of wedges now forms a single unit, which may be attached to the gun by a safety chain P. The head of wedge G has a projection R formed thereon to facilitate easy removal when the nut has been slacked off. The barrel is assembled by inserting it in the breech socket and dropping the wedges into their respective slots and grooves. (*Accepted June 9, 1920.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

144,006. A. E. Simpson, Bury. Tool for forming Taper Holes. (2 *Figs.*) March 24, 1919.—The invention relates to combined drilling and reaming tools for forming taper holes at one operation, in which the end of the tool is formed to start and continue to form the hole and constitutes the drilling portion of the said tool, and the following portion is tapered and constitutes the reaming portion of the said tool, threads extending across the whole of the surface between the spiral grooves, or flutes being formed, whereby a number of stepped cutting points are formed at the leading, or cutting edges of the reamer portion of the tool; and this invention has for its object to provide an improved tool of

this kind whereby friction on the work and the torsional strain set up in the tool, when in use, are considerably reduced, and the danger of the said tool breaking is consequently minimised. The novel feature consists in forming a number of stepped cutting points on the leading, or cutting, edges only of the reaming portion of the tool. The stepped cutting points are marked *a* and the clearances, between the cutting points which avoid, as much as possible, non-cutting frictional action against the sides of the hole, are marked *b*. The tool has the end *c* formed to start, and continue to form, the hole, the following part of the tool forming the taper and acting as a reamer. (*Accepted June 16, 1920.*)

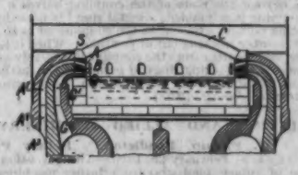
144,020. A. Smith, Keighley. Lathe Bed. (2 *Figs.*) April 4, 1919.—The invention relates to lathe beds of such formation that the surfaces which are of importance for the efficient performance of the lathe's functions are kept in perfect condition,



and consists in forming the surfaces over and upon which the saddle and loose head have to slide to act as guiding and supporting surfaces only, while a longitudinal bar is added to the lathe bed of such formation that gripping devices may be employed to act in connection therewith so that, by these being brought into action to grip the bar, the secure fixing of the saddle or loose head may be thereby effectively secured. The wearing surface *b* at the back of the bed 2 is formed approximately double the width to that usually followed, to guide the saddle 5, while within the space between the two shears *d* and *f* of the bed 2 is a longitudinal bar 3 upon the upper edge of which horizontal, inclined and vertical faces *g*, *h* and *k*, respectively, are formed in such manner as to act as the guiding faces for the loose head. The saddle 5, on taking over the lathe bed 2 has its guiding surfaces *b*, *c*, *m* and *n* as stated, and the guiding surfaces *h* and *n* are solely employed as guiding surfaces. Into the lower surface of the saddle 5, a recess is made to receive a clamping block 6 which takes loosely therein. The opening through this clamping piece 6 enables it to span, or partly encircle, the guiding surfaces of the longitudinal bar 3. Through the extending portion of the saddle 5 a screw 7, arranged to be operated by a handle 8, is made to take and to operate the clamping block 6 in order that by said clamping block 6 having a groove 6a formed therein, said screw 7, as operated, may be caused to make the block 6 yield and grip the longitudinal bar 3, thus the saddle is fixed in position upon the lathe bed by said gripping actions, without in any way having to cause any part to grip the guiding surfaces *b*, *c*, *m* and *n*. (*Accepted June 16, 1920.*)

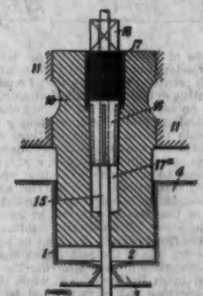
MINING, METALLURGY AND METAL WORKING.

143,049. F. G. Riley, London. Glass Melting Furnace (4 *Figs.*) May 27, 1919.—The invention relates to gas-heated glass-melting furnaces of the type known as the "Siemens," in which the gas and air are previously heated by regenerations and the flame is a cross over, that is, passing from side to side. The novel feature consists in forming the two sides of the furnace above the melting line of burner blocks each of which has in it two passages, the one for the inlet of gas and the other for the inlet of air. Each burner block B has in it two oval passages, the lower G for the inlet of gas being horizontal, while the upper A



for the inlet of air is inclined so that the air strikes the gas, and ensures the point of combustion and the greatest heat being removed from the face of the block. The passage A opens into a feeder flue A^1, to which air is supplied through ports A^2 from an air regenerator A^3. Similarly the passage G connects with a feeder flue G^1, to which gas is delivered through ports G^2 from a gas regenerator. The blocks are provided with projections and recesses for the purpose of lateral stiffening, and also with projections to support the walls and flue covers. On top of them are placed springers S carrying the crown C. (*Sealed.*)

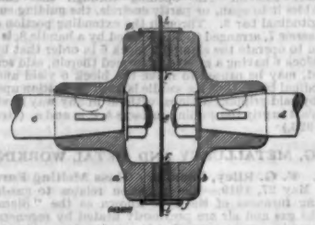
143,586. British Insulated and Helsby Cables, Limited, Prescot, and R. Cleworth, Prescot. Metal Tubes. (2 *Figs.* October 22, 1918.—The invention relates to the manufacture tubes of a desired length, from a plurality of billets of metal, such as aluminium, of medium hardness, the billets being introduced serially into a container, and then pressed upon by a ram and extruded through a die of smaller diameter than the container. According to the invention, the core, or mandril, of the press is combined with the ram and consists of a separate rod of steel passed through and adjustably fixed, or clamped, in the ram. 1 is the container in which the metal to be extruded is introduced, and from which it is pressed through the die, and 2 is a metal billet in the container, ready for being acted upon by the ram, it having a hole in its centre through which the bore forming mandril passes in the extrusion operation. 3 is the die placed directly at the bottom of the cylinder 1 and forming the seat on which one end of the billet rests, this seat or surface being partly conical and below the narrow portion of the aperture of the die, through which the metal passes, the hole is coned. The die holder 4 is carried on a delivery head having a curved passage in it which guides and directs the tube in its delivery more or less at right angles to the vertical axis of the machine. The die is



moved upwards by a ram working in a cylinder in the base of the press. 10 is the metal extrusion ram which is carried in the stationary head of the press, and its active lower end forms a "running fit" in the cylinder 1. This ram is carried in a holder 11 fixed in a socket attached to the head of the press, and it is readily detachable from the carrier 11, and conversely, fixed in position, by means of stud screws which screw through the walls of the carrier into recesses in the upper portion of the ram body 10. The mandril is marked 15 and consists of a rod separate from the ram, and passes through it; and it is adjustable in the ram, and is clamped and fixed in any position to which it is set or adjusted, by a tapered split plug 16 on the end of the threaded upper plug portion 17, which is turned by a part 18. The split portion 16 lies in a hole 17a in the ram body, the upper part of which is slightly tapered so that when the screw plug 17 is screwed down into the ram body, the split plug portion 16 is pressed on to the rod 15, and clamps it firmly. Thus, if a part of the mandril which projects beyond the ram end breaks, it can rapidly be fed down by removing the ram from its carrier 11, and slackening the plug 17, and pressing it through the ram, and then screwing up the plug again, and subsequently inserting the ram in its holder, and screwing up the studs. (*Accepted June 9, 1920.*)

MOTOR ROAD VEHICLES.

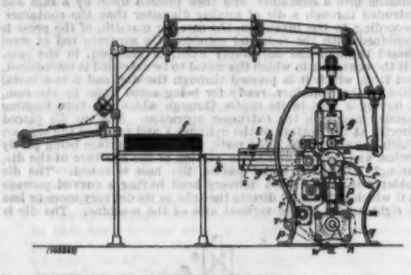
143,637. F. R. Simms, London and Simms Motor Units, Limited, London. Flexible Couplings. (3 *Figs.*) February 27, 1919.—The invention relates to flexible couplings such as are interposed between the gear-box and the driving axle of a motor road vehicle. A flexible coupling according to the invention comprises two halves *a*, *b*, which are keyed respectively to the meeting ends *c*, *d*, of the two shafts to be connected, and an intermediate member interposed between these two parts and designed to provide the requisite flexibility. This member is composed of a strip of leather *e* of an approximately rectangular shape, embedded at, or near, each end in a block of a resilient material *f*, preferably soft rubber, so that a pad of resilient



material is thereby provided on each side of the strip at each end thereof. The face of each of these pads is formed with corrugations *g* which are designed to engage with corresponding corrugations in the face of the coupling half with which it contacts. The leather strip is made of a length such that it projects at each extremity *i* beyond the ends of the coupling halves *a*, *b*, and, when the coupling is assembled, a metal ring *j* is passed through each projecting portion adjacent to the coupling so as to prevent the resilient member working out of position. When it is desired to detach the said member from the coupling it is merely necessary to remove one of the locking rings to permit of the leather strip, with the pad, being pulled or drawn out in the direction of its length. (*Accepted June* 9, 1920.)

PRINTING AND ALLIED MACHINERY.

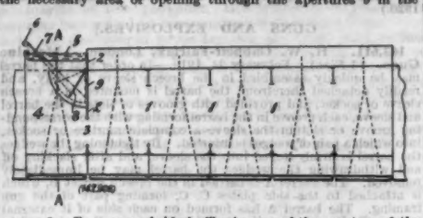
143,623. W. Pickup, Pendleton. Rotary Printing Machine. (1 *Fig.*) February 25, 1919.—The invention relates to the type of rotary photogravure printing machines which comprises a rotating copper printing cylinder, an impression roller adapted to run in contact with said cylinder, means, such as a cam and link arrangement, for moving said printing cylinder throughout every alternate revolution out of contact with said impression roller, a paper feed table and means for the delivery of the printed paper. The printing cylinder *a* is mounted in two bearings *b*, rendered slightly vertically movable in guides *c*, and above said cylinder is mounted also in suitable bearings, an impression roller *e*, between which and the cylinder *a* the paper *f* is fed to take the etching or engraving from the printing roller *a*. Above the impression roller *e*, a vertically adjustable pressure roller *g* is employed to run in contact therewith. The printing roller *a* revolves continuously and drops slightly every alternate revolution, which provides time for inserting the paper *f* in sheet form between cylinder *a* and roller *e*, and dispenses with the ordinary feed grippers hitherto necessary. A is the board



by which the sheets of paper are fed. This board is provided with wheels *i* and rendered horizontally reciprocatable on rails *k*. The feed board A is provided with lay guides *l* rendered adjustable thereon. The printing cylinder *a* is raised and dropped by means of cams *m* secured on each end of the driving shaft *n* and acting upon links *o*, vertically slidable in the frame *p* of the machine and with upper ends pivoted to the bearings *b*. The driving shaft *n* has secured thereto the cams *m* geared up with the printing cylinder *a* by means of a train of wheels *q*, *r*, *s*, *t*, so proportioned as to cause the cams *m* to make one revolution whilst the printing cylinder makes two revolutions. To get the accurate printing register, a lever mechanism is employed, worked from the cam-shaft *n* by means of the cam *u*, adapted to move the board or table A carrying the sheet *f* towards the printing cylinder *a* the required distance, the front edge of the sheet being placed slightly past the vertical centre line of the printing cylinder *a*. The said lever mechanism comprises a lever *v* having the two arms *w*, *x*, of which *w* is acted upon by the cam *u*, while the other arm *x* by means of a connecting rod *y*, is pivoted to the feed board table A and adapted to reciprocate same. (*Accepted June* 9, 1920.)

SHIPS AND NAUTICAL APPLIANCES.

143,906. Fleming and Ferguson, Limited, Paisley, and E. Dunlop, Paisley. Dredgers and Barges. (2 *Figs.*) February 10, 1919.—The invention relates to improvements in sand trapping and baffling devices for hopper dredgers and hopper barges. According to the invention, in the hopper or hold of a hopper dredger or hopper barge, between that part of the hopper or hold in which the material is deposited and the overflow, is arranged a screen extending from the top of the hopper coaming well down into the hopper or hold, and in said screen one or more apertures are provided fitted with a closure adapted to be manipulated from the deck, as required. The screen is disposed athwartship near that end of the hopper or hold from which the surplus water overflows, and extends to a distance from the bottom of the hopper or hold determined by experience, having regard to the nature of the solid material to be dealt with. 1 is the hopper or hold; 2 the screen, by means of which the surplus water in passing from the hopper or hold 1 to the overflow 5 is caused to descend to pass through the gap 3 near the bottom of the hopper before entering the passage 4 on its way to the overflow 5. When the material fills up the lower part of the hopper 1 so that the gap 3 becomes closed, then by means of the winch 6, and the chain 7, the doors 8 may be raised to give the necessary area of opening through the apertures 9 in the



screen 2. By means of side baffles in way of the apertures 9 the surplus water may be caused to flow into the passage 4 in a downward direction, thus assisting in the deposition of the lighter material in the hopper or hold. (*Sealed.*)

TEXTILE MACHINERY.

143,389. A. Carpenter, Shipley. Bobbins. (2 *Figs.*) May 21, 1919.—The invention relates to improvements in bobbins used with spinning, or analogous machinery, and refers to that class of bobbin which carries a paper tube, on to, or from which, the yarn is wound or unwound; these paper tubes vary considerably in size with the result that they are too slack or too tight on the bobbins. A metal flange F is cut away as at F1 for lightness, leaving sufficient metal to form driving lugs F2. This flange F has an upstanding boss F3, having a central aperture

for the spindle, and around the collar is attached one end of a substantially-cylindrical tube T, which is split for its total length with one slot T1, and a portion of its length with one or more other slots T2. If a double-ended bobbin is required, the upper flange F* shown by dotted lines will be provided with a depending split tube adapted to fit into the tube T. When the tube T has been extended or reduced in diameter to fit the paper tube, the inner tube to flange F* will be similarly adjusted to fit the tube T and be placed in position after the paper tube has been put *in situ*. (*Accepted June* 2, 1920.)

143,664. J. Erskine, Belfast. Treating Fibrous Material. (2 *Figs.*) March 17, 1919.—The invention relates to apparatus for treating waste fibrous material and for enabling flax waste to be used in the manufacture of felt, and to provide apparatus of the revolving screen type which will clean the material without rolling it into a rope. A is the revolving screen, B the bands and C the lathe or beaters. The revolving screen is built up from a number of rails *a* supported longitudinally between two rings *a*1, *a*2, and covered with wire gauze, fine netting, or perforated material. The rails may be arranged at an angle to the axis of the screen to make the latter conical. The two rings to which the rails are secured are grooved around their outer edge for the

Fig. 1.

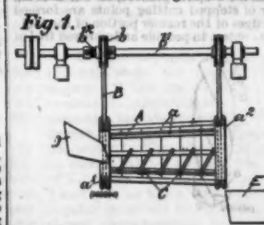
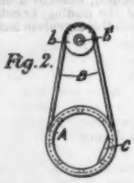


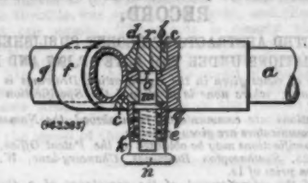
Fig. 2.



reception of the driving bands B by which they are suspended from pulleys *b* on a driven shaft *b*1. One of the pulleys is rigidly fixed on the shaft and the other is loosely mounted thereon and driven by friction through the intervention of a spring *b*2. This arrangement allows the pulley to slip in the event of any discrepancy in the driving and prevents the driving bands from coming off. The beaters C are attached to certain of the rails and are arranged obliquely thereto to traverse the material through the screen, as it revolves. The screen is enclosed within a casing to confine the dust, and the material is fed into one end through a hopper D and delivered at the other end into a bucket E. (*Accepted June* 9, 1920.)

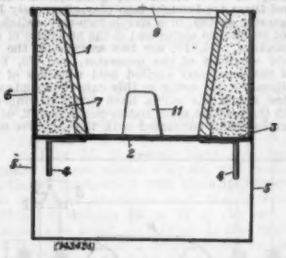
MISCELLANEOUS.

143,385. R. M. Williams, Barrow-in-Furness. Bicycles. (2 *Figs.*) May 15, 1919.—The invention relates to convertible bicycles, such as may be used by a lady or gentleman, and has reference to the type provided with a removable frame bar, which can be interchanged from the top position as in a gentleman's bicycle to an inclined position as in a lady's bicycle. The invention consists in a fastening device for the removable bar to hold it in either of the positions required. The removable bar is provided at its ends with undercut, dovetail or reduced portions *b*, adapted to fit within female portions *c* having undercut grooves or recesses *d*, such locking device comprising a tubular boss *e* secured to the joint portions *f* at the inside of the front pillar *g* and the inside of the seat pillar respectively, a third boss being fixed to a lug if required, at the foot of the seat pillar near to the driving shaft bearing of the machine. Each tubular boss *e* is provided with a central chamber *h*, in which is located a horizontal spring-controlled bolt *m* having at its outer end a head *n* by which the bolt can be drawn outwardly so that its inner end *o* will be clear of the recess *d* and admit of the top bar *a* being placed in or taken out of position in the joint portions, or to allow the forward end of the bar to be turned down against the seat pillar or tube of the main frame. A spring for controlling the bolt is located between the knob *n* and a collar *q* on the bolt, and when the latter is drawn outwardly the knob can be turned



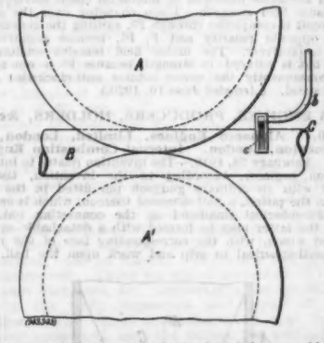
round about 90 deg. so as to hold the pin or bolt in the outward position. When the top bar is in the horizontal position the springs force the inner ends of the two top bolts into holes *r* in the lugs *b*, and so secure it in position. (*Accepted June* 2, 1920.)

143,424. J. McG. Murray, T. F. Murray, and J. G. Steven, Glasgow. Confectioners Stove. (3 *Figs.*) July 10, 1919.—This invention relates to a stove or furnace for heating pans, particularly for use by confectioners in boiling sugar, and relates to that class of stove or furnace in which the pan is supported in a furnace chamber lined with refractory material and heated from below by gas burners, the hot gases from which circulate in the furnace chamber around the pan. The furnace liner 1 is constructed in the form of the frustrum of an inverted cone, and is supported upon a bottom plate 2 having an asbestos covering 3 and supported by means of brackets 4 within an outer cylindrical sheet iron casing 5, whose lower part serves as a base



support, whilst its upper part is lined with asbestos 6, a suitable refractory composition 7, of firebrick and fireclay, being provided between the asbestos liner 6 and the furnace liner 1. Fitted over the upper part of the furnace liner 1 and the outer casing 5 is an annular cover plate formed with projections 9 for engaging a pan for boiling sugar. The projections 9 may also form recesses between them, so that the hot gases may escape through the annular space between the pan and the furnace liner. The gas burner is arranged at the bottom of the furnace chamber and projects through an opening 11 in the side of the liner 1. (*Accepted June* 2, 1920.)

143,343. D. W. Chisholm, Garnkirk. Lap-Welded Tubes. (2 *Figs.*) March 18, 1919.—The invention relates to the manufacture of lap-welded tubes in which oxygen or other gas is used to raise the scarfed edges of the pre-heated skelp to the proper welding heat. The novel feature consists in directing the gas on the seam from a box having a concave wall provided with a series of slits so arranged as to direct streams of gas on the skelp at, and in the neighbourhood of, the seam, at an angle, the angle being the same as that of the scarfed edges themselves, or being such that the streams will be tangential to the tube. The container takes the form of an arcuate gas box, to which



oxygen is supplied by a pipe *b*, the box being provided in its concave inner wall with a series of angular slits *c*, adapted to direct the gas, escaping from the box, on to the surface of the skelped strip and upon, and in between, the scarfed edges thereof. The angular slits in proximity to the scarfed edges C will direct a portion of the gas issuing from the container in between the scarfed edges and, also, the arrangement of the slits is such that this will take place. The box may be pivotally carried so that it can be readily raised out of and lowered into position as desired, and the gas is supplied to the box by a flexible pipe, the arrangement being such that when the box is lowered into the active position the gas will be automatically turned on and, when it is raised out of the active position, will be automatically turned off. (*Accepted June* 2, 1920.)

BRAZILIAN MANGANESE.—The important trade done in manganese ore exported from Rio during the war has fallen off considerably both in volume and value, says the British Chamber of Commerce, Rio de Janeiro. The decline was inevitable, as the price was considerably inflated during the war, but it may be hoped that, with better transport conditions, this excellent source for ore supplies will not be neglected. High freights from Brazil unquestionably stand in the way meantime.